WIN! RASPBERRY PI RETRO GAMING KITS

The MagPi

The official Raspberry Pi magazine

Issue 61 September 2017

raspberrypi.org/magpi

RETRO CHIC GOOGLE AIY INTERCOM

Putting voice recognition inside classic devices

SMARTER DJ DECKS

Turntables upgraded with Raspberry Pi power

BUDGET 3D PRINTING

Build your own 3D printer for a rock-bottom price

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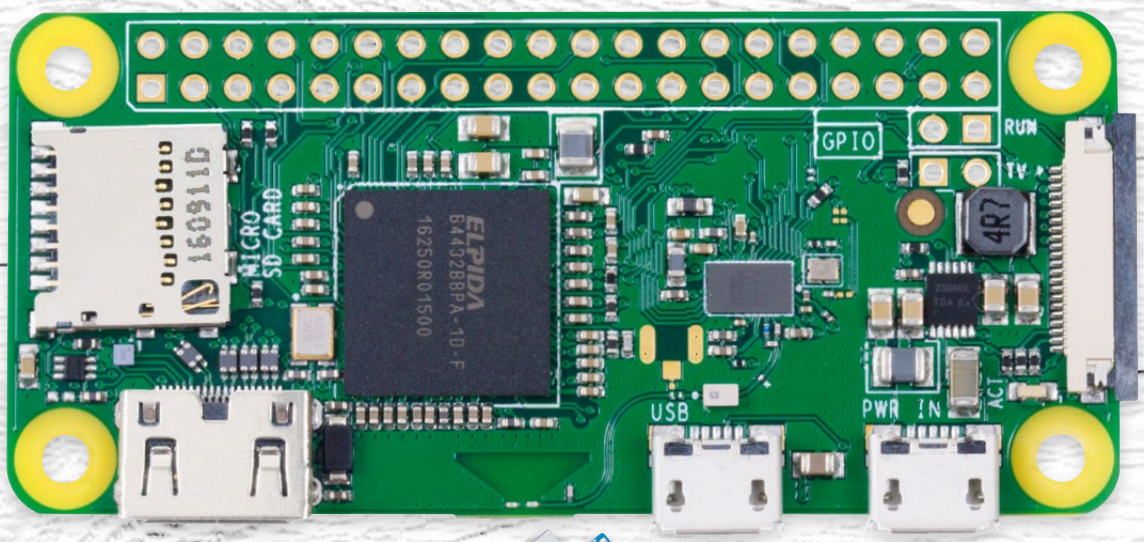
Set up smart lighting in your home

10 PI ZERO W PROJECTS YOU MUST MAKE!

INCLUDES: Video Jukebox • Mini Arcade Cabinet • AirPlay Speaker • Car Dash Cam



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- CORETEC TINY ROBOT REVIEWED
- **LEARN TEXT EDITING IN VIM AND NANO**
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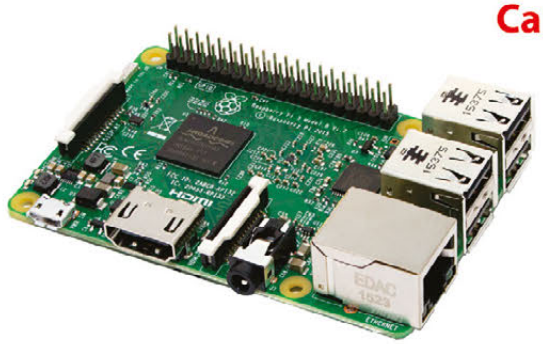

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WELCOME TO THE OFFICIAL MAGAZINE

We're always amazed by what the Raspberry Pi community builds using the Pi Zero W (Raspberry Pi's smallest wireless computer). We've seen miniature game consoles, photo frames, magic mirrors (plus other small display projects), drones, tiny robots, and smart devices around the home. The Pi Zero W is small, cheap, sturdy and, crucially, incredibly well engineered. No wonder it's so popular.

But Raspberry Pi isn't the only platform out there. Another board that's often used by digital makers is Arduino. People often think of Pi and Arduino as rivals, but they are very different devices. Raspberry Pi is a computer platform, while Arduino is a microcontroller, ideal for controlling precision elements like servos and DC motors.

Putting the two together creates an unstoppable tag team. You get more done if you stop thinking about which widget is best, and start thinking about how components could work together to get the best result.

That's why this month we've got two incredible features: 10 Pi Zero W Projects, plus Arduino and Pi. Read both features and you'll be capable of building bigger, better, and bolder projects. Never limit yourself to just one approach, device, or project. The more tools you can use, the better a digital maker you'll become.

Lucy Hattersley
Editor - The MagPi

WIN! RASPBERRY PI RETRO GAMING KITS
The MagPi
10 PI ZERO W PROJECTS YOU MUST MAKE!
FREE PI ZERO W WITH A SUBSCRIPTION! PAGE 28
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DISTRIBUTION
Seymour Distribution Ltd
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EC1A 9PT | **+44 (0)207 429 4000**

SUBSCRIPTIONS
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Photo credit: Raspberry Pi – Anna Gordon

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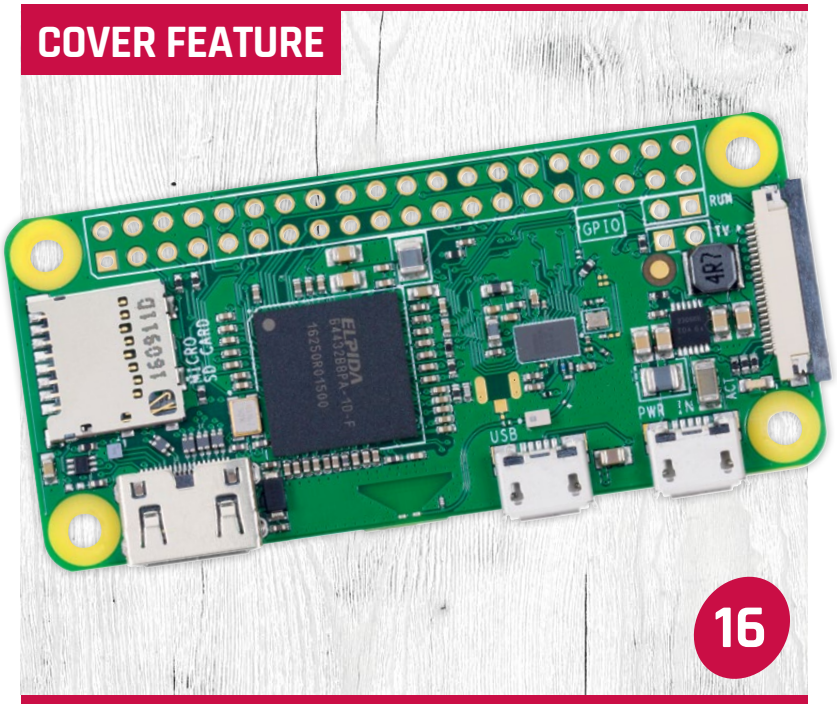

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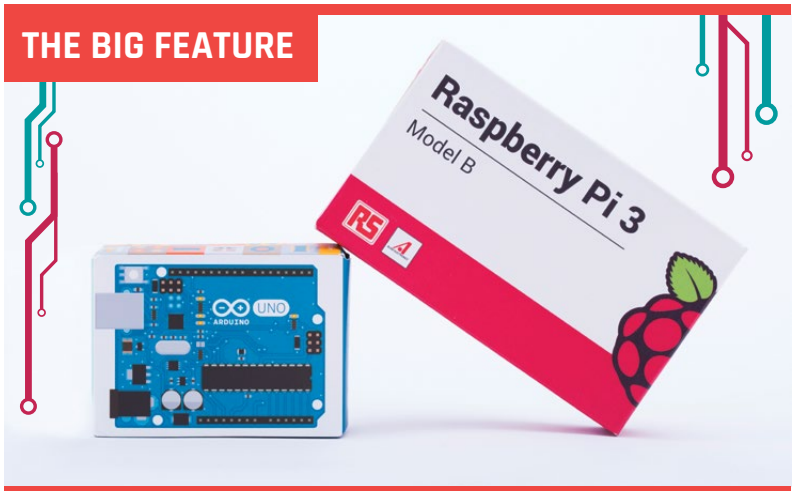

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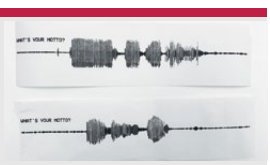

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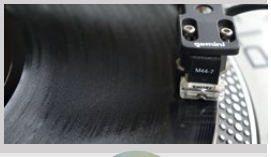

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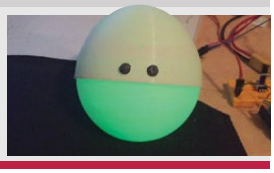

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TEN MILLIONTH RASPBERRY PI MADE IN WALES

British Raspberry Pi manufacturing proves hugely successful

The Sony UK Technology Centre (Sony UK TEC) has announced the production of the ten millionth Raspberry Pi made in the UK.

Raspberry Pis were originally made in China, but in 2012 Sony UK TEC was contracted to make 10,000 units. However, a Sony UK TEC spokesperson confirmed that the facility "went on to produce one million [Raspberry Pi boards] in its first year."

Steve Dalton, Sony UK TEC managing director, said, "The last five years have seen unprecedented growth across our Pencoed facility – something we are understandably proud of."

The Pencoed facility was chosen, a Sony UK TEC spokesperson explained, "due to the facility's capacity and innovative automated processes." Based roughly 13 miles west of Cardiff, the Sony UK TEC facility "has seen staff numbers leap by 200, taking its team of local employees to 540" over the last five years.

Steve added, "Our growth has been intrinsically linked to the success of the Raspberry Pi. This is a significant achievement for everyone involved in its production, especially our devoted Sony Team, The Raspberry Pi Foundation, and distributors Premier Farnell."

Raspberry Pi co-founder Eben Upton joined Sony UK TEC to celebrate the milestone, saying "when we initially began manufacturing [Raspberry Pis] here at Sony UK TEC, we could never have imagined it would be the soaring success it has become – and for that we are grateful to Sony and our distribution partners."

Right Eben and the team at Sony UK TEC celebrating the landmark ten millionth Welsh-made Pi

Above Gareth Jones and Joe Whaley from Sony with Romain Soreau from RS and Sarah Fawcett from Premier Farnell

Made in Britain... in Japan?

Eben attributes much of the success of the Raspberry Pi to Sony UK TEC's "unparalleled manufacturing standards, comprising the latest techniques and the very best engineering talent."

> "Our growth has been intrinsically linked to the success of the Raspberry Pi"

Steve Dalton added that making Raspberry Pis in such volume "has challenged our highly skilled team of engineers and technicians to develop new processes and drive innovation. We were able to support The Raspberry Pi Foundation further by introducing Pi manufacturing to our counterparts in Japan, and there is now a 'made in Japan' version of Pi."

No Raspberry Pi 4 yet, though

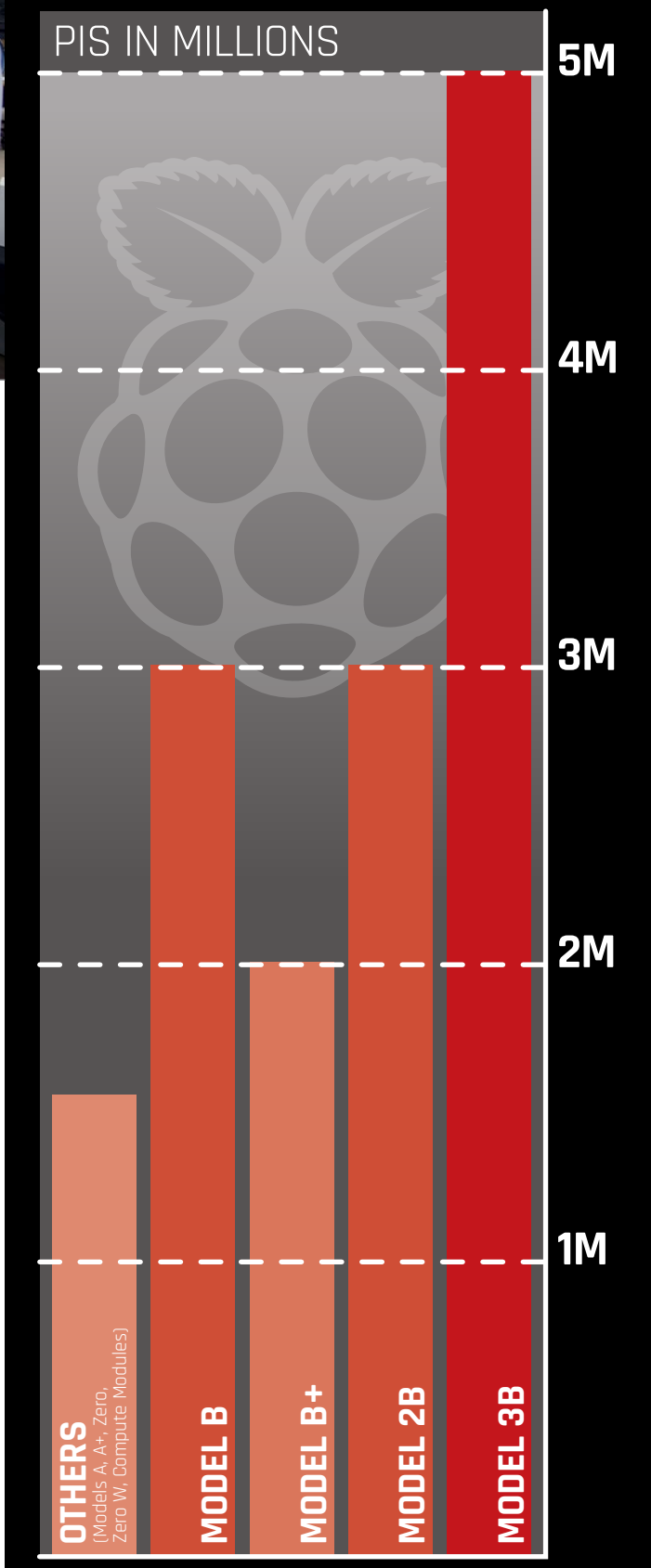
Speaking with Beta News (**betanews.com**) at a separate event, Eben was asked whether we might see a Raspberry Pi Model 4 sometime soon. His response was, "Nope!"

Eben clarified: "I think we gave the impression by launching Pi 2 and Pi 3 a year apart that we were establishing some sort of annual cadence. We've said that we think the Raspberry Pi 3 is more of a three-year platform."

Even that is a very soft timeline, though, as Eben added, "we're not much more than a year into that (very rough) window yet."

Left Eben (left) with Steve Dalton, Sony UK TEC managing director

HOW MANY PIS IN THE WORLD?



MINI MAKER FAIRE AT THE INSTITUTE OF IMAGINATION

Fuelling kids' imaginations with a full head of STEAM

London-based charity, the Institute of Imagination (IoI, **www.ioi.london**) hosted a Mini Maker Faire at its Imagination Lab on 29 July.

The event featured activities from retro computing and laser cutting to robot football. We caught up with Corrie Jones, IoI interim marketing manager, after the show. "We're really happy to have had so many people attend, and to see so many children get so involved in all of the activities," she told us.

Above RedRobotics' SoccerBotz were a hit at the IoI's Mini Maker Faire

> "One child had created a robot that would pick up all the rubbish from the bottom of the ocean"

Below Each SoccerBotz houses a Raspberry Pi and an Arduino

"Our current theme is 'Teaching Me', and is all about inventing things that you think will make a positive impact in the future. One child that I spoke to had created a robot that would pick up all the rubbish from the bottom of the ocean. Inventions [like that] show a really high level of thinking about what we need to improve the world."

Pi-powered robot football

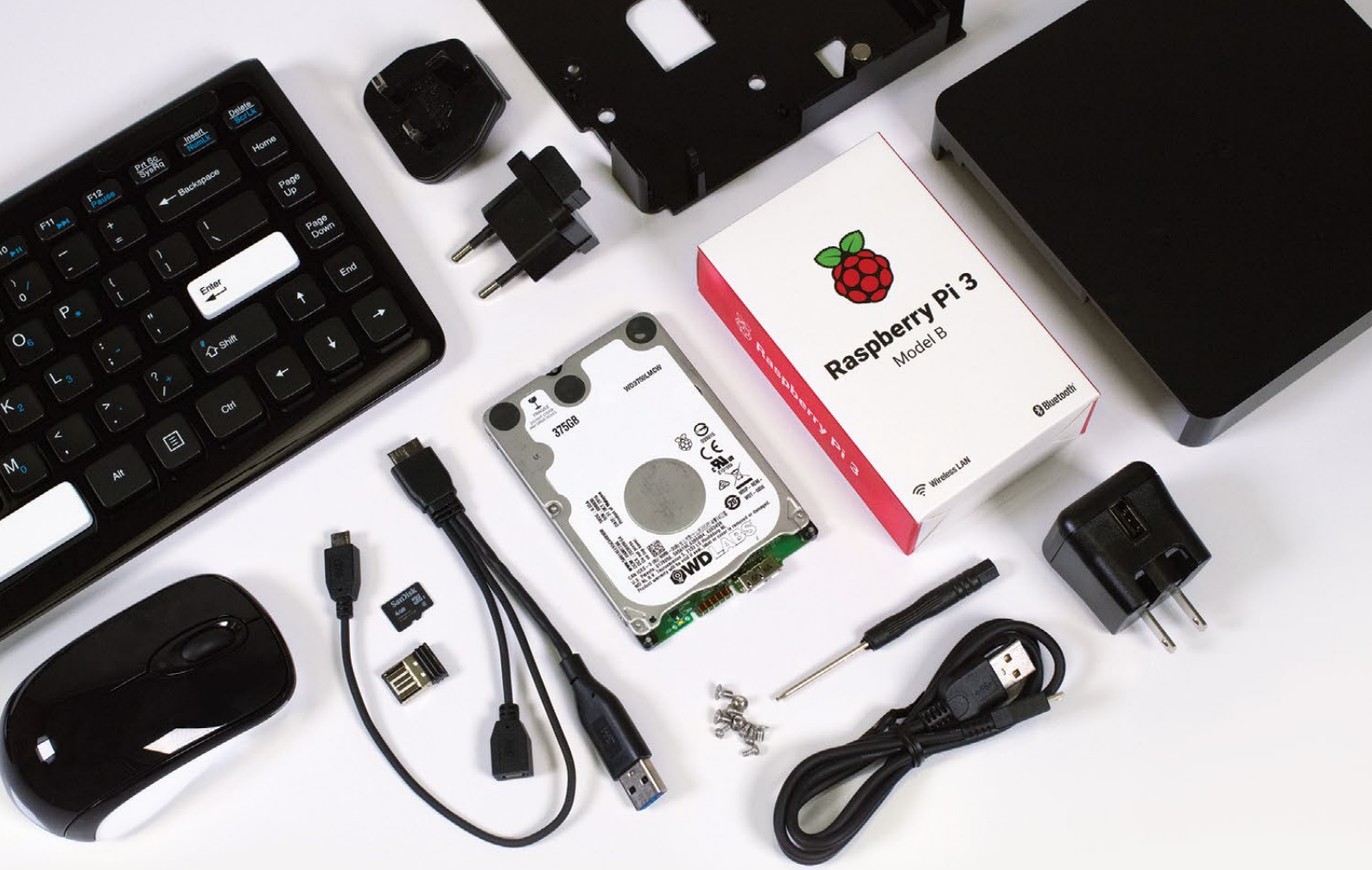
Red Robotics (**redrobotics.co.uk**) brought some SoccerBotz to make a three-a-side Pi-powered robot football game. "That was brilliant," remarks Corrie. "I didn't get to have a go on it myself because it was so busy throughout the day!"

The SoccerBotz used a Pi to handle the remote-control instructions and motors, but also used an Arduino to run the power control system. The Arduino can be programmed directly from the Pi, as we explain in our guide starting on page 60.

STEAM power

IoI focuses on STEAM learning, adding art and design to science, technology, engineering, and maths. So, "as well as there being science and technology elements," to IoI events, Corrie says, "the arts and things that [kids] can make and feel really proud of" also feature.

The IoI runs many weekend activities, all aimed at children, families, schools and teachers, and covering everything from film-making to coding and 3D design. Visit **ioi.london/whats-on** for details, or contact the IoI at **hello@ioi.london** to bring an 'Imagination Pod' to your school.



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ZEROCAM RELEASED

A bespoke Pi Zero camera range

The Pi Hut (**thepihut.com**) has released the first full range of cameras designed specifically for the Pi Zero. The cameras are smaller than the standard official Raspberry Pi Camera Modules, and connect directly to the smaller CSI ports of the Zero boards.

The range includes a standard camera, a fish-eye camera, and a NOIR infrared camera. Despite the module's reduced size of just 11.4×11.4 mm (compared to the 25×23 mm of the standard Module), it still packs a 5MP sensor (compared to the 8MP of the V2 Camera Module).

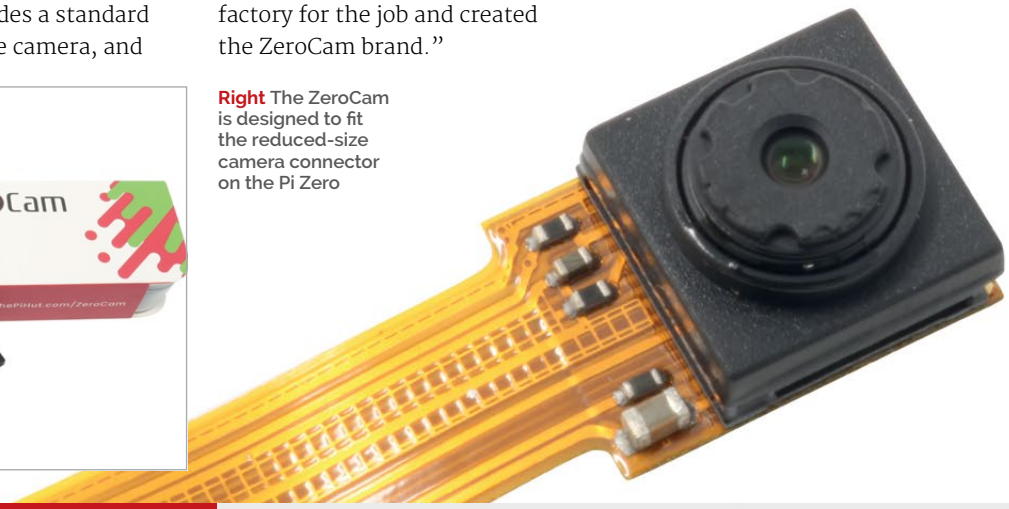
The Pi Hut's Jamie Mann tells us, "We sampled a bunch [of camera modules] from various manufacturers, found the best factory for the job and created the ZeroCam brand."

Jamie explains that the ZeroCams "work with the existing camera code." He also predicted that we'll see smaller camera connectors on future models of the Pi: "There are already smaller ones out there… it'll happen!"

The ZeroCam, ZeroCam FishEye and ZeroCam NOIR cost £15 each from **thepihut.com**.

Below Each ZeroCam comes in a metallic case with magnetic clasp – sounds like a body cam case to us!

Right The ZeroCam is designed to fit the reduced-size camera connector on the Pi Zero



PIONEERS WINNERS ANNOUNCED

Who 'Made it Outdoors' the best?

The next Pioneers challenge will be set in September

The winners of the second Pioneers challenge, a digital making projgram for 11-16 year-olds, have been announced.

The overall theme winner is HH Squared's Pi Spy project.

Pioneers challenges young people to work together to create a piece of technology addressing a theme, with this cycle's theme being 'Make It Outdoors'.

Pioneers organiser Oly Brown says of HH Squared's project, "We really loved how every member of the team contributed [and] how tech was used to enhance the enjoyment of the outdoors."

The Pioneers challenge isn't just about making something, but the process of trying to make something. Coding Doughnuts won the Inspiring Journey prize by explaining all the problems they encountered while trying to build a smart picnic hamper.

Equally, Uniteam's "great explanation of such a wonderful project" earned it the Best Explanation prize. Watch their YouTube video, Plantz with a Z (**magpi.cc/2vfHueC**).

Don't miss the next Pioneers challenge – sign up to the newsletter at **magpi.cc/20MN2rc**.

AIY PROJECTS NEEDS YOUR VOICE

New open-source project to make voice-based making easier

Google's new Open Voice Project aims to make AIY Projects 'more responsive' by providing 'a set of open-source voice keywords to use.'

But the project needs your help: the more people who provide a sample of their voice, the better the speech recognition gets.

"We have around 2,000 recordings of each word so far," Google engineer Pete Warden tells us, "but the more diversity in accents we can get, the more people the speech detection will work for." As a Brit abroad, Pete has often found himself having to spoof an American accent to make voice systems work.

The project is only aiming to "enable a very basic voice interface", Pete reveals, with single-word commands like 'stop' or 'open'.

Pete also confirms that the Open Voice Project will always be open: "We will be releasing the recordings under a Creative Commons BY 4.0 licence," he discloses.

You can help the project now by turning on your microphone and heading to **magpi.cc/2wm005I**.

Below Google's new project should decrease the learning time for DIY voice-based builds

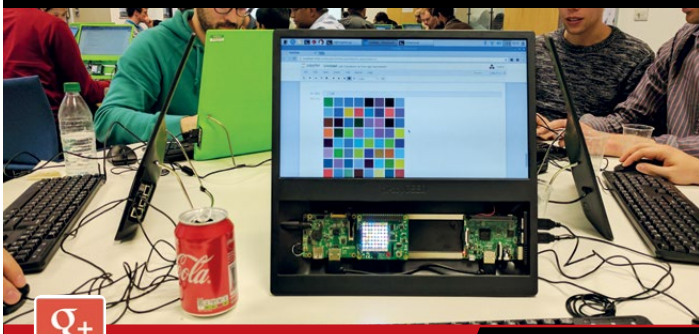
NOW TRENDING

The stories we shared that flew around the world

RASPBERRY PI DESKTOP CHALLENGE

magpi.cc/2tMa3jf

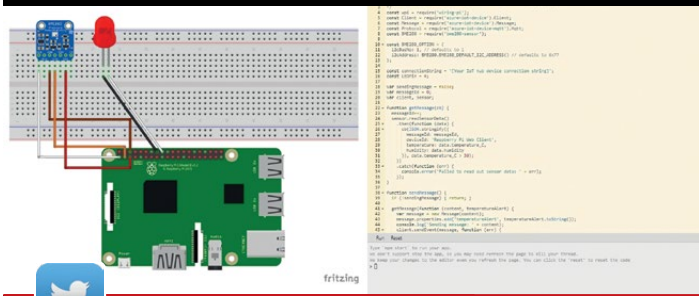
Can you really use a Raspberry Pi 3 as your main computer? After all, that quad-core 1.2GHz processor and 1GB of RAM should be plenty for office work. Follow the link to see if it's possible!



JULIA LANGUAGE NOW ON PI

magpi.cc/2tEUcCT

Julia, a next-generation coding language for data analysis and scientific research, is now available on the Pi. With the claimed 'speed of Fortran and ease of Python', Julia's a decent choice for hobbyists, too.



MICROSOFT'S PI SIMULATOR

magpi.cc/2usunnP

Microsoft has launched an online Raspberry Pi simulator. It's early days, but it could be a useful way to prototype projects without breaking out the breadboard – never mind the soldering iron!

Wells can be managed through a smartphone app as well as at HQ

BETTER OIL DRILLING WITH A RASPBERRY PI

Pi-based smart controller increases revenue by $7,000

Texas-based Petrolog Automation (**petrologautomation.com**) has created a smart oil well monitor that increases the revenue from each well by a reported $7,000 (roughly £5,300). The smart monitor is based around a Raspberry Pi and a custom-made cellular modem.

The need for a smart meter arises at so-called 'marginal wells' (also, we are told, referred to as 'stripper wells'). As Carlos Labrado, software developer at Petrolog, clarifies: "these wells are low-production wells that are often thought of as not worthy of a POC [Pump Off Condition] controller."

people going to the well every day. Also, our controller is smart, so it finds the best times to be pumping and thus increases production."

Carlos tells us that Petrolog chose the Raspberry Pi for version one due to its size, low cost, and features. "Now we keep using it because of the great support community... like resinOS."

> "Our controller is smart, so it finds the best times to be pumping and thus increases production"

As the fluid level in these marginal wells fluctuates, an engineer must visit each well every day to ascertain the fluid level and set the pump accordingly. Some of these wells are over four hours' drive away.

Carlos explains the benefit of Petrolog's POC controller: "[It] saves money by not having the well turned on when there is not enough fluid, and not having

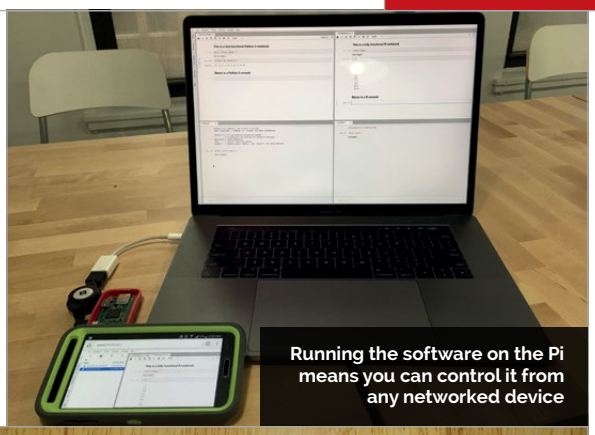
Left Spot the Pi embedded in Petrolog's custom-made cellular modem and casing

Resin.io

The Pi embedded in the Petrolog POC controller runs resinOS (**resinos.io**), a dedicated Internet of Things (IoT) operating system from resin.io. Alison Davis, director of product marketing and strategy, explains, "Because resin.io uses Docker containers to deploy updates, the Petrolog team can change the application running on their oil well monitors as often as they like, without fear of bricking devices."

"Anybody can get started with resin.io," Alison tells us, "whether you're a hobbyist with a few devices at home, or a professional with a fleet of thousands." She confirms that the free resin.io account accommodates up to five devices.

USING A PI AS A PLUG-IN PROCESSOR



Running the software on the Pi means you can control it from any networked device

Big data in little Pi

Scott Edenbaum, a recent graduate from the NYC Data Science Academy (**nycdatascience.com**), has turned a humble Pi Zero into a data crunching, code trialling, data science-ing auxiliary processor.

Wanting to avoid "the potential for security exploits" of installing MySQL on his main development computer, Scott instead used virtualisation software Docker (**docker.com**) to create standard environments for Python and R (a programming language suited to data science).

Scott's approach avoids the "multiple (possibly conflicting) dependencies" of Python and R, while allowing him to create his sandbox coding and testing environment quickly and easily. Building the environment from scratch each time is "a process that takes 2+ hours on a Raspberry Pi 3", let alone a modest Pi Zero.

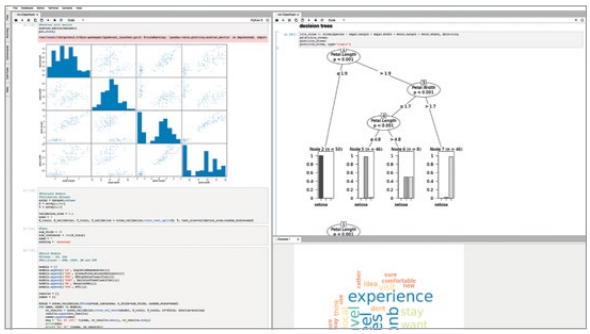
Crunching big data sets doesn't need to involve big hardware

Plug-in processor

"Because the device is so inexpensive, I can see there being a lot of possibility using it for education" Scott tells us, while the standardised environment saves "headaches" such as installing libraries and managing package repositories.

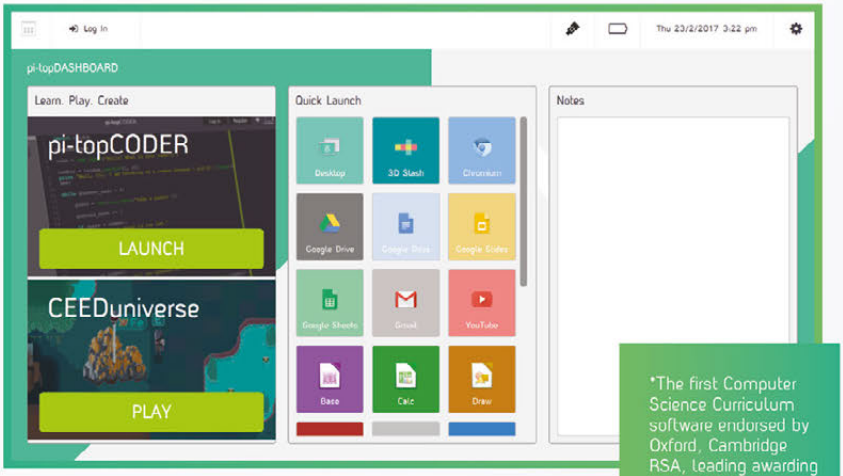
Scott's project could replace Excel "for some tasks", while Docker "allows deployment and management of a few devices or hundred, without too much extra work." He says there are "a lot of interesting cases I haven't thought of."

The project is on GitHub at **magpi.cc/2uh3guV**, and Scott has documented the installation process at **magpi.cc/2fmMPdJ**.

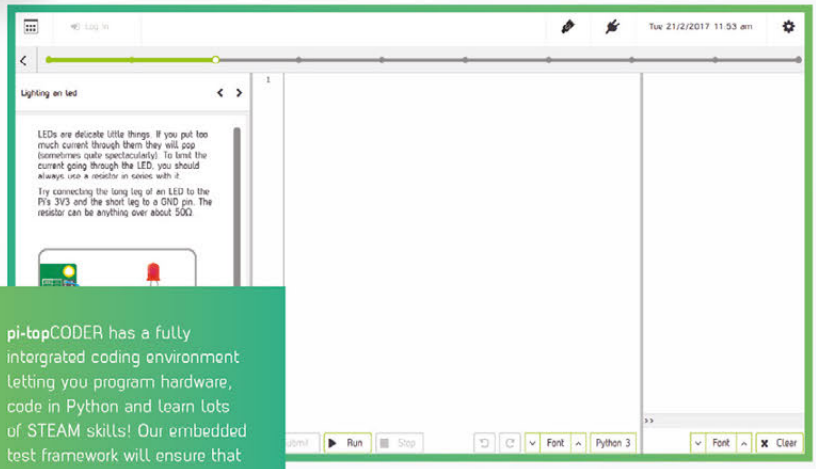


pi-topOS

The OCR* endorsed **pi-top**OS (Operating system) platform comes pre-installed on the 8GB SD card shipped with every unit. **pi-top**OS software suite lets you - browse the web, - check emails, - create and edit Microsoft Office compatible files. It includes **pi-top**CODER and comes with the revolutionary educational game CEED**universe**.



*The first Computer Science Curriculum software endorsed by Oxford, Cambridge RSA, leading awarding body - **OCR**.



pi-topCODER has a fully intergrated coding environment letting you program hardware, code in Python and learn lots of STEAM skills! Our embedded test framework will ensure that you understand all concepts.

pi-topCODER

pi-topCODER is the interface that allows you to access worksheets and pre-built Raspberry Pi projects. It's the easiest way to tinker or deliver lessons by providing step-by-step guides for computer science and STEAM worksheets.

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CEEDuniverse is our educational game. It's a world of fantasy developed in line with the computing curriculum – taking science fiction and transforming it science. It is a FREE massive role-play game carefully crafted by **pi-top**. The game teaches students to solve computational puzzles, how to code in Python and build physical circuits which interact with the game.

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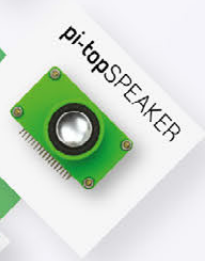

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10 PI ZERO W PROJECTS YOU MUST MAKE!

The Pi Zero W is a fantastic piece of kit, and these pages are packed with ideas to inspire your Pi Zero creativity

Adding wireless internet connectivity to the original Raspberry Pi Zero was at the top of many people's wish lists when it was first launched. A real computer, amazingly small, with a built-in internet connection – this opens up so many possibilities for amazing projects.

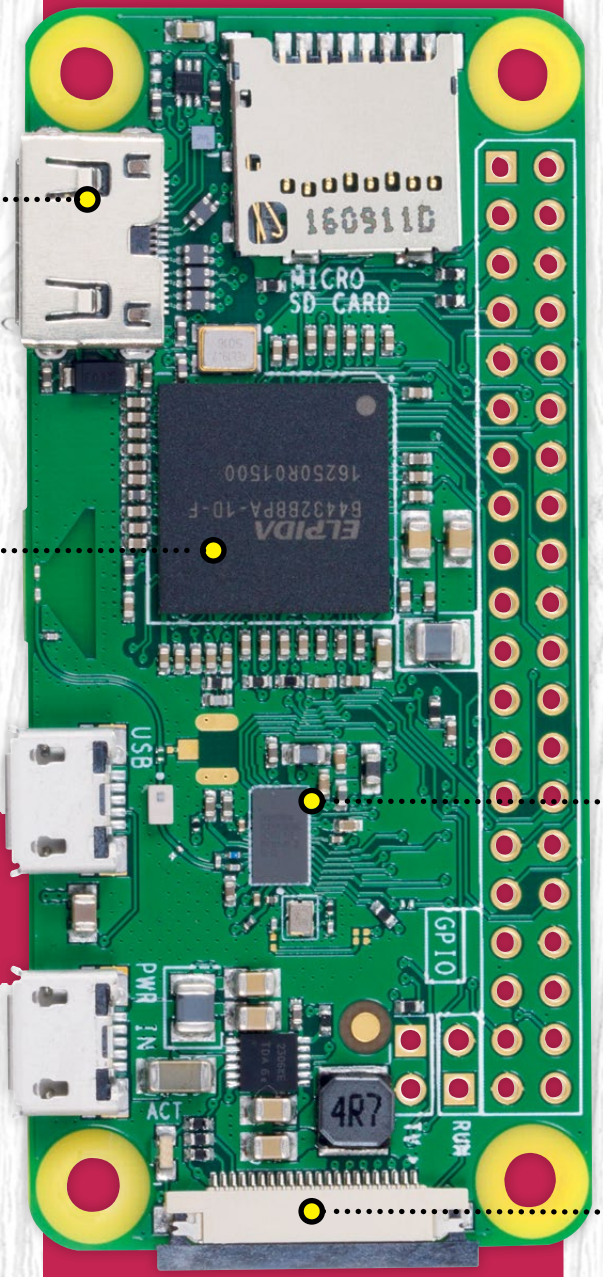
Since its release in February 2017, the Pi Zero W has been used in many amazing builds around the world, so we thought it was about time to highlight some of the exciting things you can do with the newest member of the Raspberry Pi family, and the original Pi Zero as well. Let's get making!

MINI HDMI

Connect to an HDMI display to create your own media PC or interactive project

SYSTEM ON A CHIP

This features the same CPU as in the original Raspberry Pi, although it's clocked a little higher



WIRELESS CHIP

Connect to a wireless network or Bluetooth with the radio chip on the Pi Zero W

CAMERA CONNECTOR

The Raspberry Pi Camera Module can be added for photography projects – all you need is an adapter cable

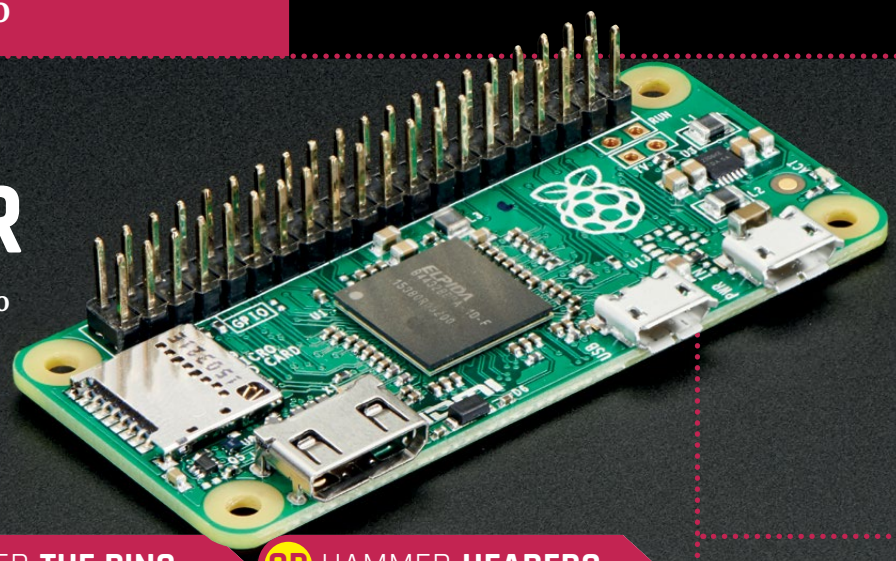
GETTING STARTED

Quick tutorials for your Pi Zero

While you can do a lot of things with the Pi Zero, it's worth sharing a few tips to help you use it in even more projects. These can be as simple as software tweaks to improve performance and reduce power requirements, or adding hardware to make it easier to integrate into your projects. Here are some of our favourites.

ATTACH A GPIO HEADER

Add GPIO pins to your Raspberry Pi Zero



YOU'LL NEED

- 40-pin male header
- Soldering iron and solder

01 GET READY TO SOLDER

Put the short legs of the 40-pin header through the GPIO holes on the Pi Zero. We like to turn it upside down so the side of the Pi Zero with the header is raised off the floor, giving a perfect view of the pins to solder to the board.

02 SOLDER THE PINS

Let your soldering iron heat up and then solder the individual pins. Make sure no solder crosses between the pins or you may short them out. Be careful – soldering irons are extremely hot, so let the solder cool before touching it!

OR HAMMER HEADERS

Pimoroni has an excellent solution to adding a GPIO header to the Pi Zero: a special header that can be hammered into the holes with a special kit. You can find out more on Pimoroni's site: **magpi.cc/2lohN2U**

CONVERT THE USB PORT

Connect USB accessories quickly and easily

A lot of micro USB to USB A converters can be bulky, using wires and full-sized female USB A ports. A great alternative is to use a micro USB shim, which is only as big as the connector. This allows you to convert the data port while losing minimal space.

OR You can buy HATs and other add-ons to add USB ports to the Pi Zero without making the Pi Zero wider or longer, but these options will more than double its height. If you're feeling extremely brave, you could try removing the micro USB and soldering on a standard USB A connector, but we don't recommend it unless you really know what you're doing.

ADD COMPOSITE VIDEO OUT

Using an old telly? Here's how to use it as a display for a Pi Zero

YOU'LL NEED

- Two-pin header
- 2× female-to-male jumper wires
- Screw terminal with RCA connector

TOP TIP

If the video looks wrong, switch the jumper cables over on the Pi Zero

01 SOLDER TO THE PI

Look to the top right-hand corner of the Pi Zero and you'll see two holes labelled TV, below the GPIO holes and next to two pins labelled RUN. Put the short ends of the header through the TV holes, flip the Pi over, and solder them on.

02 CONNECT THE RCA

Slot the jumper wires onto the headers, and put the other ends inside the screw terminals of the RCA plug. The Pi Zero should automatically switch to this output when you plug it into a TV.

CONNECT TO WIRELESS ON THE COMMAND LINE

It's tricky but doable – here's how!

01 GATHER INFORMATION

You'll need to know the SSID and the password of the wireless network. You can run a scan of available wireless networks using `sudo iwlist wlan0 scan`

02 CONFIGURATION FILE

Open the **wpa-supplicant** file with:

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

Go to the bottom of the file and enter:

```
network={
    ssid="[Name of network]"
    psk="[Password for network]"
}
```

TURN OFF BOOT TO DESKTOP

Improve speed and power efficiency for projects that don't use a display

In Raspberry Pi Configuration (which can be found in Menu > Preferences on the desktop, or by running `sudo raspi-config` in the command line), you can change the boot options. This includes booting to the graphical desktop, as well as auto-login. Turn off Boot to desktop and activate Auto-login, and your Pi will boot up more quickly and free up more computing resources.

TROUBLESHOOTING

Having trouble with your Pi Zero? Check our previous issue for an exhaustive troubleshooting guide, which includes specific fixes for the Pi Zero: magpi.cc/magpi60

RASPBERRY PI ZERO WIRELESS ACCESS POINT

Extend your router's range or turn your wired hotel internet into a wireless wonderland

A few years ago, when the Raspberry Pi was fairly new, Adafruit produced an excellent guide to creating something called the Onion Pi. The concept was to take a Raspberry Pi, connect it to the internet, and then connect to the Raspberry Pi via WiFi. Once connected, you could then access the internet, encrypted via the Tor network. You can read the original instructions here: **magpi.cc/2vCkTqq**.

We're going to do something a little more straightforward, and remove the Tor functionality. So this will be a simple, tiny, wireless access point.

YOU'LL NEED

- Latest version of Raspbian
- USB Ethernet adapter
- An extra wireless dongle (advanced)

01 PREPARE THE RASPBERRY PI

We need a lot of software to get the wireless access point working. First, update your Raspberry Pi with:

```
sudo apt-get update
sudo apt-get upgrade
```

Then install:

```
sudo apt-get install hostapd bridge-utils
```

You'll need to turn off some of the new services you've just installed using:

```
sudo systemctl stop hostapd
```

02 BRIDGE THE DEVICES

This works best with an Ethernet connection, but you should be able to use a wireless connection – with some caveats. We need to bridge the connection between the internet (`eth0`) and the wireless network (`wlan0`).

Edit the DHCP file by first using `sudo nano /etc/dhcpcd.conf` and add `denyinterfaces wlan0` and `denyinterfaces eth0` to the bottom of the file. Save and exit, and then create a bridge with:

```
sudo brctl addbr br0
```

Connect the network ports with:

```
sudo brctl addif br0 eth0 wlan0
```

03 BRIDGE INFORMATION

Open the network interfaces file with `sudo nano /etc/network/interfaces`, then change the `wlan` info to `manual`.

```
allow-hotplug wlan0
iface wlan0 inet manual
```

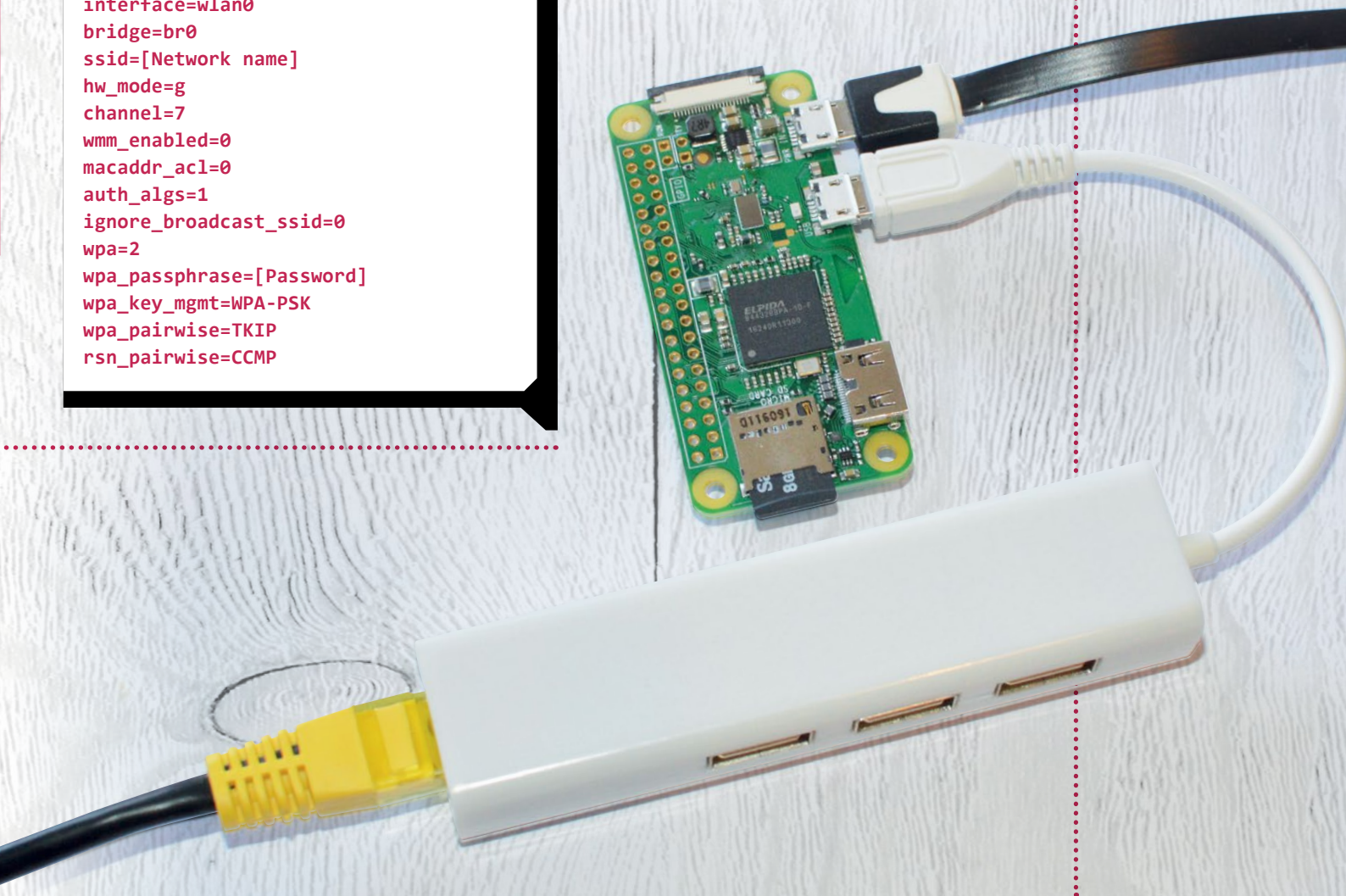
With that done, add the information for the bridge to the file.

```
# Bridge setup
auto br0
iface br0 inet dhcp
bridge_ports eth0 wlan0
```

04 CREATE THE ACCESS POINT

Now, we need to edit the **hostapd** file to allow another computer to connect to the Raspberry Pi. Open the file with `sudo nano /etc/hostapd/hostapd.conf` and add the following, putting in your own network name and password:

```
interface=wlan0
bridge=br0
ssid=[Network name]
hw_mode=g
channel=7
wmm_enabled=0
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_passphrase=[Password]
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP
rsn_pairwise=CCMP
```



05 FINAL TWEAKS

Save the conf file and open another file with `sudo nano /etc/default/hostapd`. In this file we can tell the system where to find the configuration file we edited. Find the line `#DAEMON_CONF` and replace it with:

```
DAEMON_CONF="/etc/hostapd/hostapd.conf"
```

Save, exit, and then reboot the Raspberry Pi. You should now be able to connect to it from another device.

WIRELESS CAVEATS

Bridging wireless connections is doable, but it can be tricky. A lot of wireless networks don't allow auto-connection, or require you to know the password in the first place. If you're using free WiFi, there may also be a landing page you have to sign into first, which may cause problems for the bridged computer.

MAKE A PI BLUETOOTH TAG

RFID-style technology for automation and more

We've seen some great projects that use Bluetooth tags and larger Raspberry Pis. With the Pi Zero W, you can create a smaller tag that slips easily into your pocket. There are many applications that support this, but here's how to get your tag set up.

YOU'LL NEED

- PyBluez – magpi.cc/1VOuGCy
- Bluetooth tag or another Bluetooth device

01 INSTALL THE SOFTWARE

Python doesn't come with a built-in Bluetooth module, so we need to install **pybluez** to our Raspberry Pi. Do a standard **sudo apt-get update** and **sudo apt-get upgrade** before you start. Once that's done, install the following:

```
sudo apt-get install python-pip
```

This is pip, the Python module installer. It works like **apt-get**, but has a different repository of software. We can then install **pybluez** using:

```
sudo pip install pybluez
```

02 TAG ADDRESS

You can use specific Bluetooth tags that send out a signal and MAC address, or you can set an existing device like a PC or phone to transmit its Bluetooth signal, which the Pi can detect. If you're using a tag, you could carry it with you and leave your Pi Zero at home.

A tag will usually tell you what its MAC address is, but Windows, Android, and iOS all use slightly different methods for other devices. Use Google to look up how to find the Bluetooth MAC address for your device.

03 WRITE YOUR CODE

Now you know your MAC address, you can plug it into the tag code listed on this page. The code is simple – it scans the surroundings once every 20 seconds and looks for the specific Bluetooth MAC address. If it finds the correct address, it lets you activate the next stage, whatever you want that to be. With that in place, you can start using this setup to automate your projects!

BT_TAG.PY magpi.cc/PiZeroWProjects

```
#/usr/bin/env python

import time
import bluetooth

tag = "ff:ff:ff:ff:ff:ff"

def search():
    devices = bluetooth.discover_devices(duration=5,
                                         lookup_names = True)
    return devices

while True:
    results = search()

    for addr, name in results:
        if addr == tag:
            # perform function

    time.sleep(20)
```

> With the Pi Zero W, you can create a smaller tag that slips easily into your pocket

HOW TO USE A BLUETOOTH TAG

Creative projects for your Bluetooth tags

ART PROJECTS

In issue 44 we explored an amazing art installation called Lichen Beacons, which used Bluetooth tags to create an interactive display. It's a wonderful idea, and the concept could be used to activate specific home automation tasks as you walk around your house, or to create a recorded walking tour for a museum: **magpi.cc/2tPnw7t**

WAKE-ON-LAN

An old favourite, this project sends a magic WoL packet signal to a computer to turn it on when the Bluetooth is detected. We produced a tutorial on this, way back in issue 47–find it at: **magpi.cc/2vD7e4e**

BLUETOOTH UNLOCK

Using an actuator, a bit of code, and a motor controller attached to the Pi, you can use the tag to unlock a door when you stand near it for a certain amount of time. One less key to carry around with you!

10 AMAZING PI ZERO PROJECTS

Need some inspiration to put your Pi Zero to work? Here are some of the best Pi Zero projects out there!

VOICE CHANGER

magpi.cc/2vEnZfU

KEY PARTS

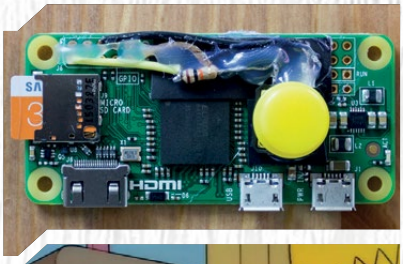
- Microphone
- Speaker

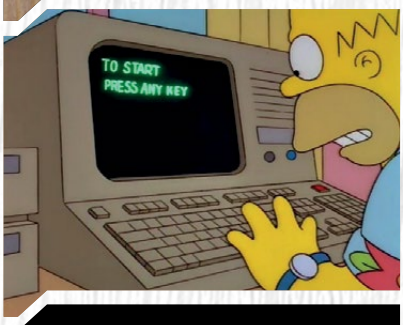
The Raspberry Pi Zero is great for cosplay, as you can do some pretty complex things with it while secreting it away in a hidden nook of your outfit. Voice amplifiers or distorters are something many cosplayers will consider at some point, depending on their costumes.

We like the simplicity of this version, using a clip-on microphone. The sound is input to and modified by the Pi, before being sent to the attached speaker. This version is used for a Star Wars Mandalorian bounty hunter costume, which is really cool, but the project could be adapted for other cosplay as well.

VIDEO JUKEBOX

magpi.cc/1TpeBBB





KEY PARTS

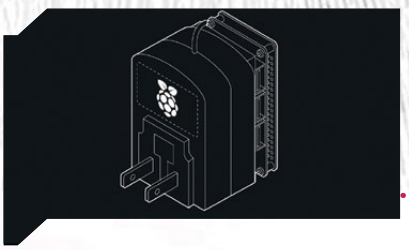
- Button
- Video files

Popularly known as the Simpsons Shuffler or Simpsons Button, this very simple Pi Zero project features a selection of Simpsons episodes. When you press a button, the Pi Zero plays a random episode. Obviously, you could do this with any media (even music), and all it requires you to do is solder a button to a GPIO pin and load a Python script. For the full Simpsons experience, there's a 3D-printed case design you can download as well.

If you are choosing Simpsons episodes, we suggest limiting yourself to seasons three to eight. You'll thank us later.

PI ZERO POWER CASE

magpi.cc/2v5tGRl



KEY PARTS

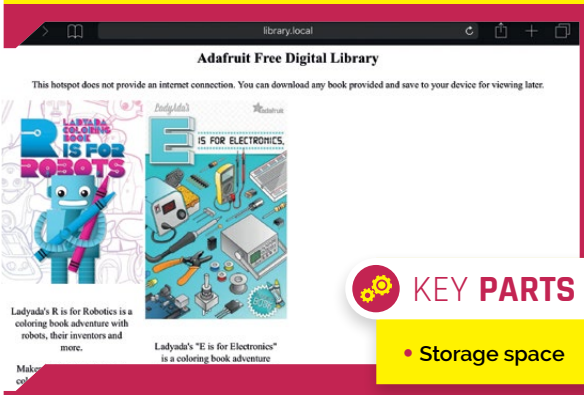
- USB power supply

This is a simple but excellent idea: attaching a Raspberry Pi Zero to a USB power adapter so that the form-factor of the computer is the same size as a plug. This can then be used to run a mini server, or even as a travel computer. This version of the project by NODE on YouTube also includes a USB hub, so you can easily connect storage and other peripherals to the Pi Zero.

The video includes a guide on how to build the power supply. Be careful – you're dealing with mains power! Don't take any risks with this project.

DIGITAL FREE LIBRARY

magpi.cc/2vpcARa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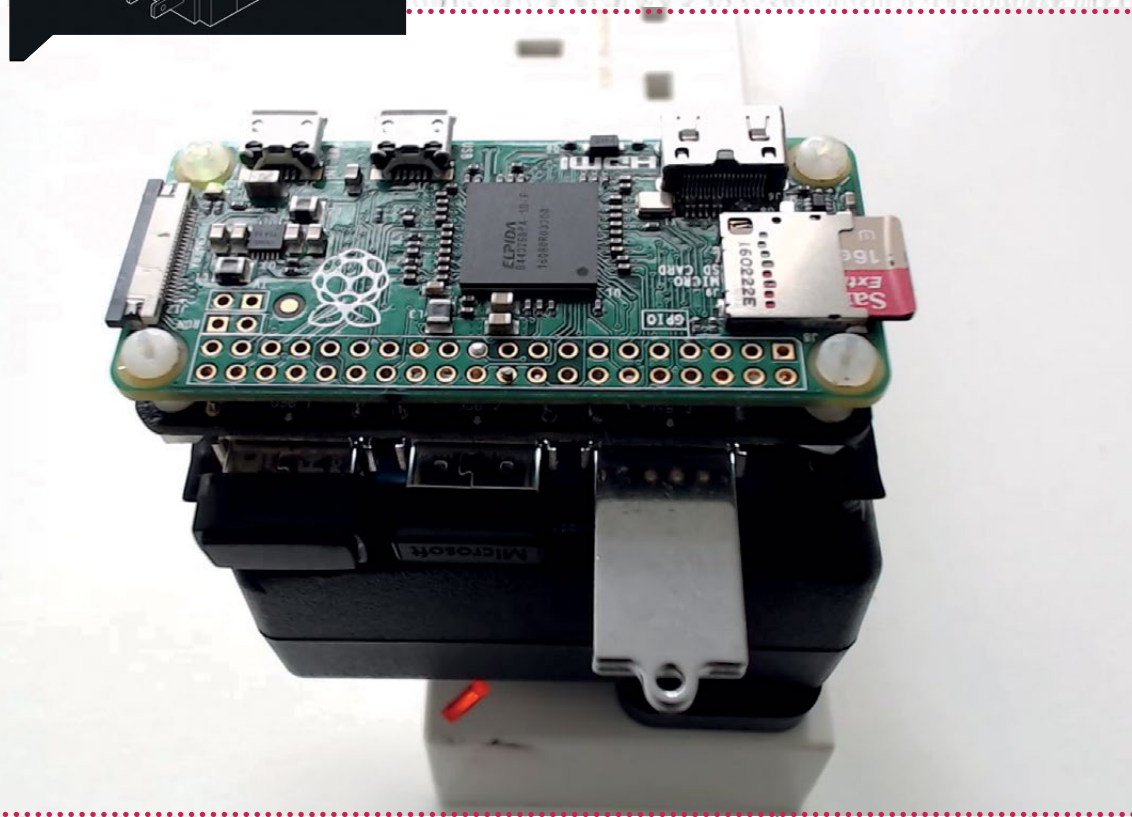
R IS FOR ROBOTS
E IS FOR ELECTRONICS
Ladyada's R is for Robotics is a coloring book adventure with robots, their inventors and more.
Ladyada's "E is for Electronics" is a coloring book adventure

KEY PARTS

- Storage space

Libraries are great, even in today's digital world. A quiet workspace – and importantly, free books! While we think of traditional libraries as inhabiting large buildings in town centres, full of resources and slow computers, we've also seen cute little libraries spring up in defunct phone boxes and other locations. This project takes the mini library concept one step further, and allows for the easy and free sharing of digital books and other e-publications.

This project comes straight from Adafruit, so there's a very thorough guide to creating your own digital learning repository. Books can be accessed via a web browser on a PC or a mobile phone, after you've connected to the Pi Zero as a wireless access point.



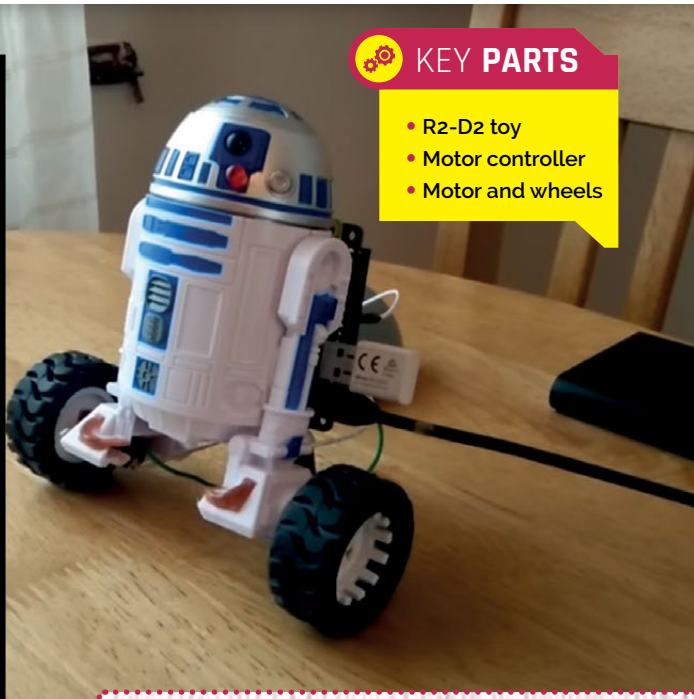
PI-POWERED R2-D2

magpi.cc/2viC8Np

Disney and Lucasfilm might want to push BB-8 as the new coolest sidekick, but we all know that R2-D2 is the best droid in the Star Wars universe. Making your own remote-controlled R2 is an extremely popular maker hobby, so much so that the version of R2 that appears in the new Star Wars films is one of these hobby-builds (**magpi.cc/2wAFbAM**).

This version is a little more straightforward, and instead of creating a one-to-one replica of the astromech, it's a mod of a small toy. This makes it much easier to hack using a Pi Zero and some small motors.

It might be a bit tricky to track down that particular R2-D2 toy these days, though...



KEY PARTS

- R2-D2 toy
- Motor controller
- Motor and wheels

MINI ARCADE CABINET

magpi.cc/2vx4yFS

KEY PARTS

- Prototype board
- 0.96-inch screen
- Laser-cut case

We'll be honest here: this project is more about what you can do with the available technology than about making a neat, portable arcade cabinet. It's so small that it's not particularly comfortable to use, but that doesn't mean it's not an incredible feat of Raspberry Pi engineering.

The back of the cabinet is the same size as the Raspberry Pi Zero, while the front is a little deeper than the board. It uses a tiny 0.96-inch OLED screen, with a resolution of 96×64, perfect for the oldest of arcade games. The buttons are soldered to some custom-made prototype boards, and the case is a custom design in laser-cut acrylic. Adafruit themselves say the design process was more of a challenge than anything else but hey, it would be a cool project to break out at a party.

MAGIC MIRROR

KEY PARTS

- Old monitor or TV
- Two-way mirror
- Wooden frame

magicmirror.builders

The magic mirror project is a popular Raspberry Pi project, and while it is usually made using a Raspberry Pi 3, there's no reason why you couldn't use a Pi Zero. Especially now that the Pi Zero W has wireless capabilities, so you'll only need power and HDMI connections to get it working.

If you've not seen this project before, it's actually incredibly easy to make. The carpentry skills required aren't very sophisticated, and the software part is all taken care of. You just need to run the specific install script and then customise it to your tastes. It's also very modular, so you can add and remove features very easily.

DASH CAM

magpi.cc/2e89hWt

KEY PARTS

- ZeroView

The ZeroView is a cool and cheap add-on for the Raspberry Pi Zero that allows you to connect the Pi Zero, via suction cups, to a window. It includes a special mount for the Raspberry Pi Camera Module that means it can film through the window at the same time.

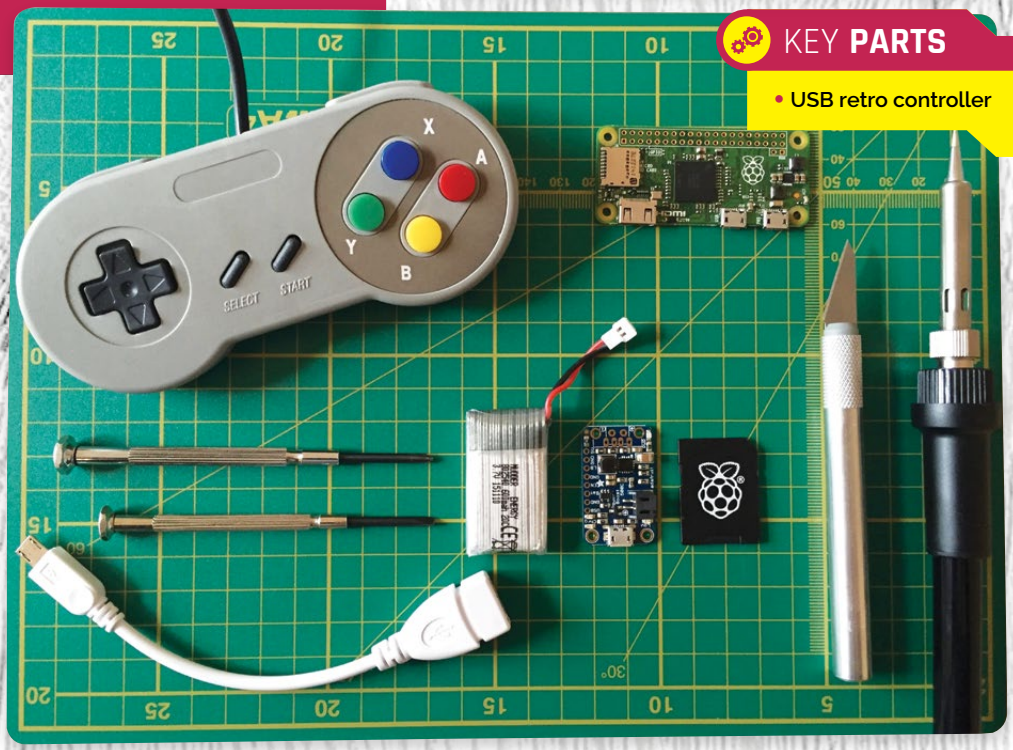
With very little in the way of additional coding and accessories, you can easily turn it into a dash cam for your car, keeping an eye on the road ahead just in case. It could even be used on track days to film your amazing lap-times!

USB RETRO CONTROLLER

magpi.cc/2vqkTtm

Projects like this are surprisingly easy, and we've covered a couple like them in the magazine before: from quick, simple hacks of NES controllers, to installing a rechargeable battery system into a fully enclosed SNES emulator.

All you need to do is find a way to connect the controller's USB cable to the Pi Zero. You can swap the USB connector for a micro USB connector; you can solder each individual USB wire to the Pi Zero's USB port if you're feeling brave; or solder them to the GPIO and make some modifications to the code. RetroPie lets you very quickly and easily configure your Pi Zero to play old games, and from there it's up to you how you use it.



KEY PARTS

- USB retro controller

PI ZERO AIRPLAY SPEAKER

KEY PARTS

- DAC
- Amp
- Wooden case

We find that AirPlay doesn't always work when we want it to, even between Apple devices – but when it does work, it's seamless and lovely. This project tries to bring the magic of AirPlay to Raspberry Pi with a wireless speaker powered by a Pi Zero. Just throw songs to it and voilà – a portable speaker.

This version of the project features an amazing wooden case that would look at home in a room with other fancy devices, but you could always make an acrylic or 3D-printed case if you prefer.

magpi.cc/2vBrgwI

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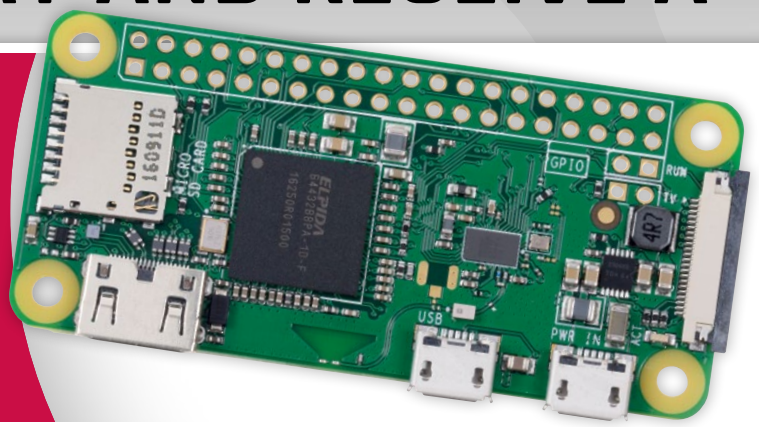

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MARTIN MANDER

Martin has 13 Raspberry Pis, many earning their keep around the home he shares with his wife and two children. He works as an analyst in Norwich.
magpi.cc/2vPQK6E

Quick Facts

- A set of three intercoms originally cost £99.95 in 1986
- Martin bought his set for a bargain £4
- He put the Pi behind the case's grille
- The case was coated with matt-finish craft paint
- He'd like to include a manual rotary volume control

GOOGLE PI INTERCOM

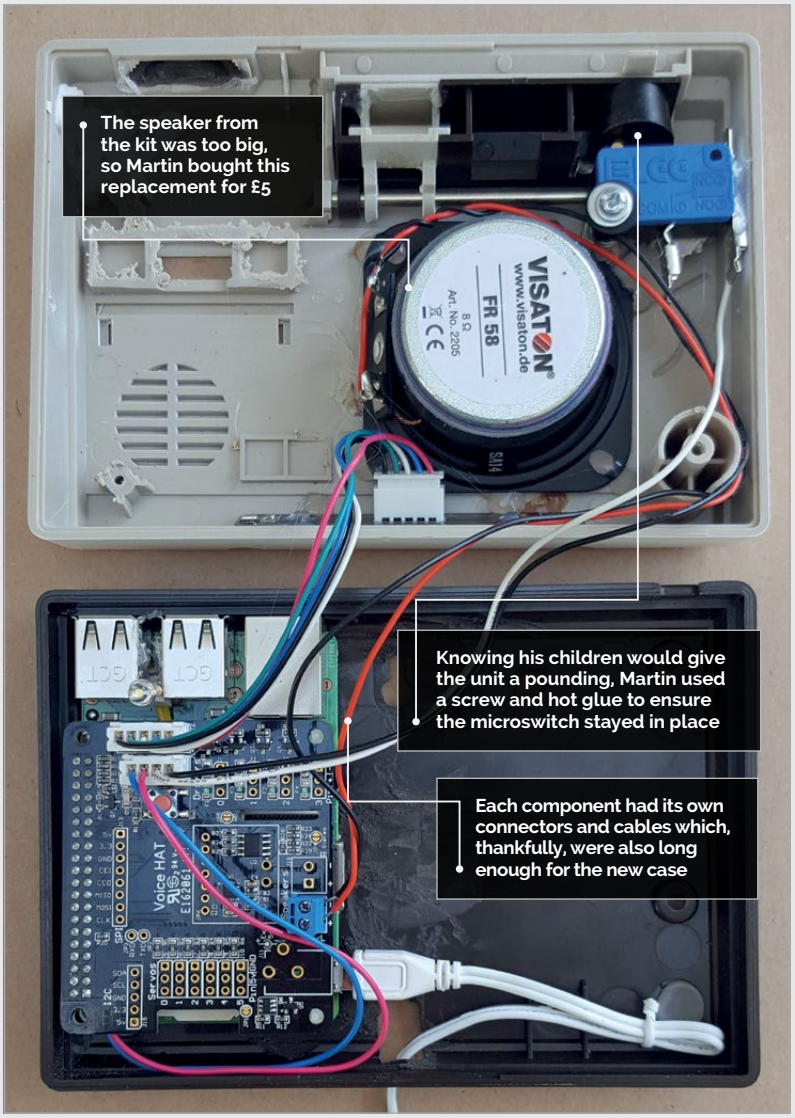
Eager to evoke a sense of nostalgia, retro nut **Martin Mander** decided to place his Google AIY kit inside an old FM wireless intercom

When Martin Mander saw *The MagPi* was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

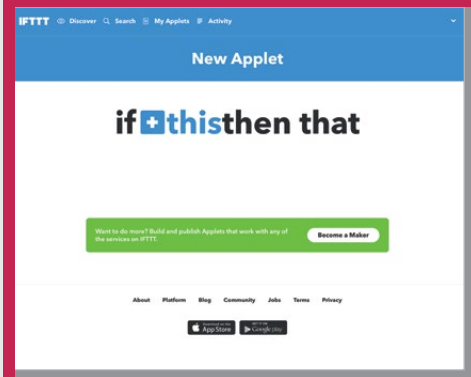
Ironic, then, that he promptly delved into the past. "The family and I enjoy the local car-boot sales and I'm always looking for old, obsolete or broken technology that I can use in projects," he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it'd be fun for the kids to be able to chat between their rooms. "They didn't work, and so I shelved them in the workshop," Martin continues. "Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way."

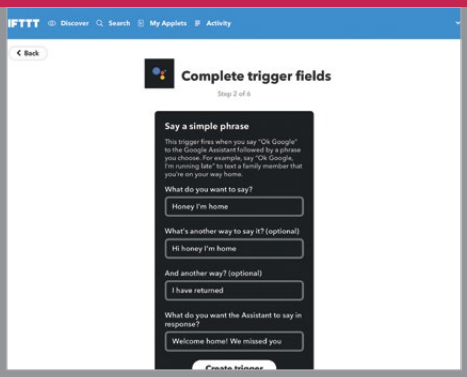
Martin's idea was to fit the Google AIY kit into one of these old units. "I'd followed the instructions in *The*


The speaker from the kit was too big, so Martin bought this replacement for £5
VISATON
www.visaton.de
FR 58
Knowing his children would give the unit a pounding, Martin used a screw and hot glue to ensure the microswitch stayed in place
Each component had its own connectors and cables which, thankfully, were also long enough for the new case

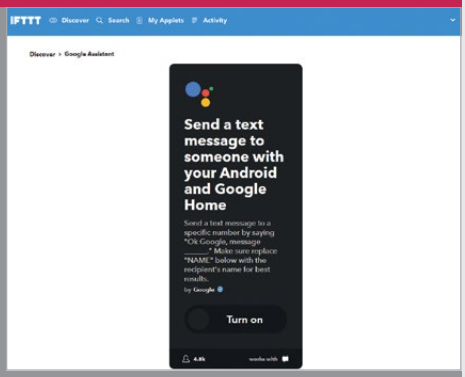
A CONNECTED HOME



>STEP-01
Using IFTTT
Martin wanted to expand the Google Pi Intercom's abilities, so he logged into **ifttt.com**, clicked My Applets, selected New Applet, and then clicked the '+' icon on the next screen.


IFTTT
Complete trigger fields
Say a simple phrase
What do you want to say?
Honey I'm home
What's another way to say it? (optional)
Hi honey I'm home
And another way? (optional)
I have returned
What do you want the Assistant to say in response?
Welcome home! We missed you

>STEP-02
Finding Google Assistant
Having searched for Google Assistant and clicked Connect, he signed into his Google account. He could then select a trigger and fill in the phrases that would activate it.



>STEP-03
Organising the response
His idea was to get the intercom to send a text to his wife when he says he's home. He chose SMS as the action service and filled in his mobile number.

MagPi to assemble the HAT and get the software up and running on the Pi," he recalls. With the Pi and HAT running on his desk, he tested some voice commands before getting on with the task of cracking open the old intercom. "There's always a slight feeling of naughtiness in ignoring the 'do not open' warning and seeing what's inside," he says. "The great thing about older tech is things tend to be screwed or bolted together, allowing them to come apart nicely, leaving just the case."

Having made lots of tiny measurements, he was convinced the kit would fit, so he cleaned and

Left The project used a repainted and cleaned intercom bought from a car-boot sale

> "There's always a slight feeling of naughtiness in ignoring the 'do not open' warning"

spray-painted the front of the case, let it dry, and began bolting the Pi into the case, adding the other components around it. "I set aside the green push-button from the kit, but kept the microswitch and fixed it inside the case alongside the big hinged intercom button."

Getting the microswitch in exactly the right place was the greatest challenge and it involved lots of trial and error: "Because it was being activated at an angle by the rear of the button, even a couple of millimetres made the difference between the microswitch sticking 'on' or there being too much play in the action."

Martin then removed the LED from its case and soldered in a two-hole component connector to secure it between the Pi's USB ports, under the original microphone grille. "The kit's microphone board was just glued into place once I'd drilled holes in the top of the case. Once that was in place, I connected the cables and closed the case."

Martin is pleased with the result: "The kids have described it as fancy and futuristic, which I'll happily take." He has since linked the intercom to his IFTTT account (see 'A connected home' box). "This took some configuring," he concludes, "but thinking up responses for the intercom to read out when the triggers are activated was really good fun."

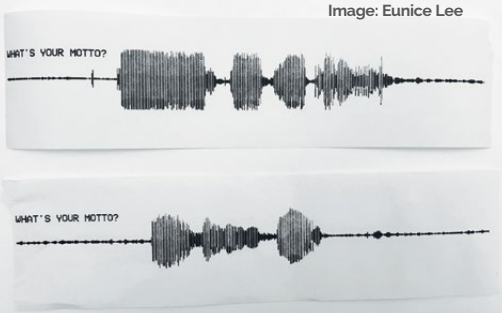
MATT, BOMANI & EUNICE

Matt Zheng, Bomani McClendon and Eunice Lee are students of design and computer science at Northwestern University in Illinois.
magpi.cc/2vANCvc

WAVES

Turn the sound of your voice into a printed waveform

Image: Eunice Lee



Above Two printouts of different responses, both answering the question on the left

Quick Facts

- The project took 7-8 hours to make
- A controller script handles subprocesses
- There's no maximum recording length
- The same amount of paper is used each time
- Build details and code are on GitHub **magpi.cc/2vANCvc**

"I'm grateful for finishing this project," says maker Eunice Lee as she holds a button while speaking into a large silver microphone. A printout of the sound waves produced by her voice emerges from the device's thermal printer.

This is a demonstration of Waves, a side project created by Matt Zhang with Eunice Lee and Bomani McClendon, students of design and computer science at Northwestern University in Illinois.

"During our first meeting, we shared some inspiring hardware projects we'd seen, and had a brainstorm session where we drew out lots of wild, funny, and weird project ideas on Post-it notes," recalls Bomani. "Afterwards, we voted on the ideas and filtered them by feasibility, materials cost, and (most importantly) excitement. We chose Waves,

Below Matt Zheng looks pleased with the thermal printout of his answer – we wonder what he's grateful for!

Image: Matt Zheng

What's your motto?
Make a wish!
What are you grateful for today?
Give us your best laugh
Holding the relevant colour-coded button, the user records their answer
Users choose to answer one of four open-ended questions
The thermal printer plots a waveform of the recorded response

Image: Eunice Lee

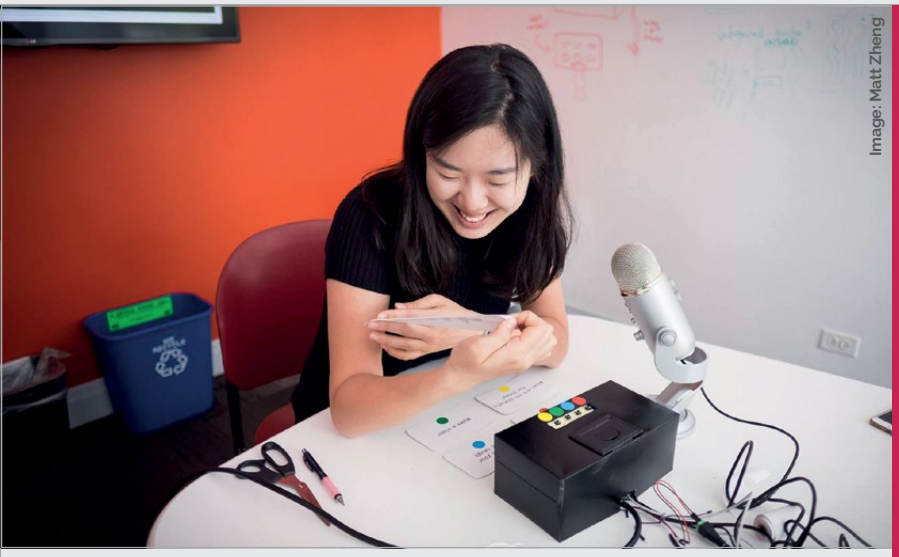


Image: Matt Zheng

and later learned that Raspberry Pi would work well for the project."

Meeting for weekly sessions, it took the trio two to three months to create the finished project. "We encountered a fair number of problems during every work session, but we managed to overcome them by the end," reveals Matt.

"Having a couple of ground rules set from the beginning really helped," reckons Eunice. "For instance, we decided to always meet once a week and to commit to a project that would take less than ten hours to build. This kept the project lightweight, fun and stress-free."

> "We all brought different skills to the table, but a mutual excitement for Waves and what it could be"

"For me, the best part of this project was getting to work with Eunice and Matt," says Bomani. "We had a lot of laughs during our sessions."

"We all brought different skills to the table, but a mutual excitement for Waves and what it could be," adds Eunice.

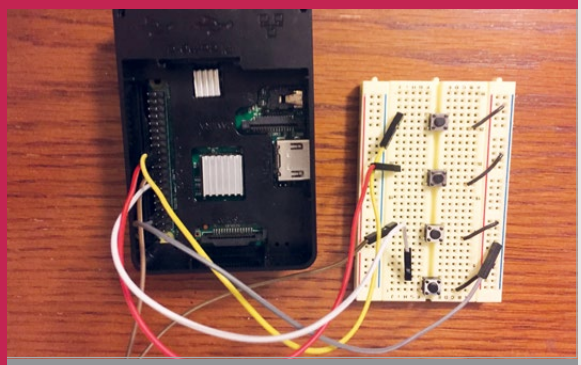
After brainstorming ideas for open-ended questions for users of Waves to answer, the team narrowed them down to the final four. "We wanted the questions to be personal and reflective," explains Eunice. "That way, receiving a print of the sound waves would mean more to the participant."

A Python script converts the recording of the user's answer into a graphical waveform to print. "The programming wasn't too tricky, since we borrowed a lot from open-source Python code," says Matt. "The plots take up the same amount of paper, no matter how long the recording is, but we have to manually adjust the volume on the microphone, to make sure that the audio doesn't blow out or disappear entirely."

The result can also be uploaded to a locally hosted website, which was displayed on a monitor during an annual Design Expo at the university. "The idea for the website was that people could see other people's sound waves and wonder what was said," says Eunice. "It was a really fun addition that turned some heads and made people interested in what our project was."

Eunice was delighted with the overall reaction to Waves: "It was really great to see people's faces light up when they finished recording and saw their sound waves being printed. [...] The best part was being able to give that to the user and say, 'You can keep it!'."

PRINT OUT YOUR VOICE



>STEP-01
Press a button

Four push-buttons – one for each question – are placed on a breadboard and connected to the Raspberry Pi's GPIO pins. The user holds down a button while recording their response.

>STEP-02
Box and printer

The Pi and buttons are placed inside a cardboard box, spray-painted black, along with a tiny thermal printer bought from Adafruit (**magpi.cc/2up57jH**) – any similar model will do.

>STEP-03
Colour coding

The four questions are printed on cards with coloured stickers matching the ones next to the push buttons on the device. A cool-looking Blue USB mic records the user's voice.

Images: Matt Zheng

DANIEL JAMES

Daniel James is the director of 64 Studio Ltd, which produces, integrates, and documents free and open source software for media.
64studio.com

Quick Facts

- Daniel estimates a Pi Deck setup costs $182
- There is no soldering or modification to the turntable
- Audio Injector sound cards cost around £20
- A Serato CV02 control vinyl pressing is recommended
- The FLAC music format gives the best results

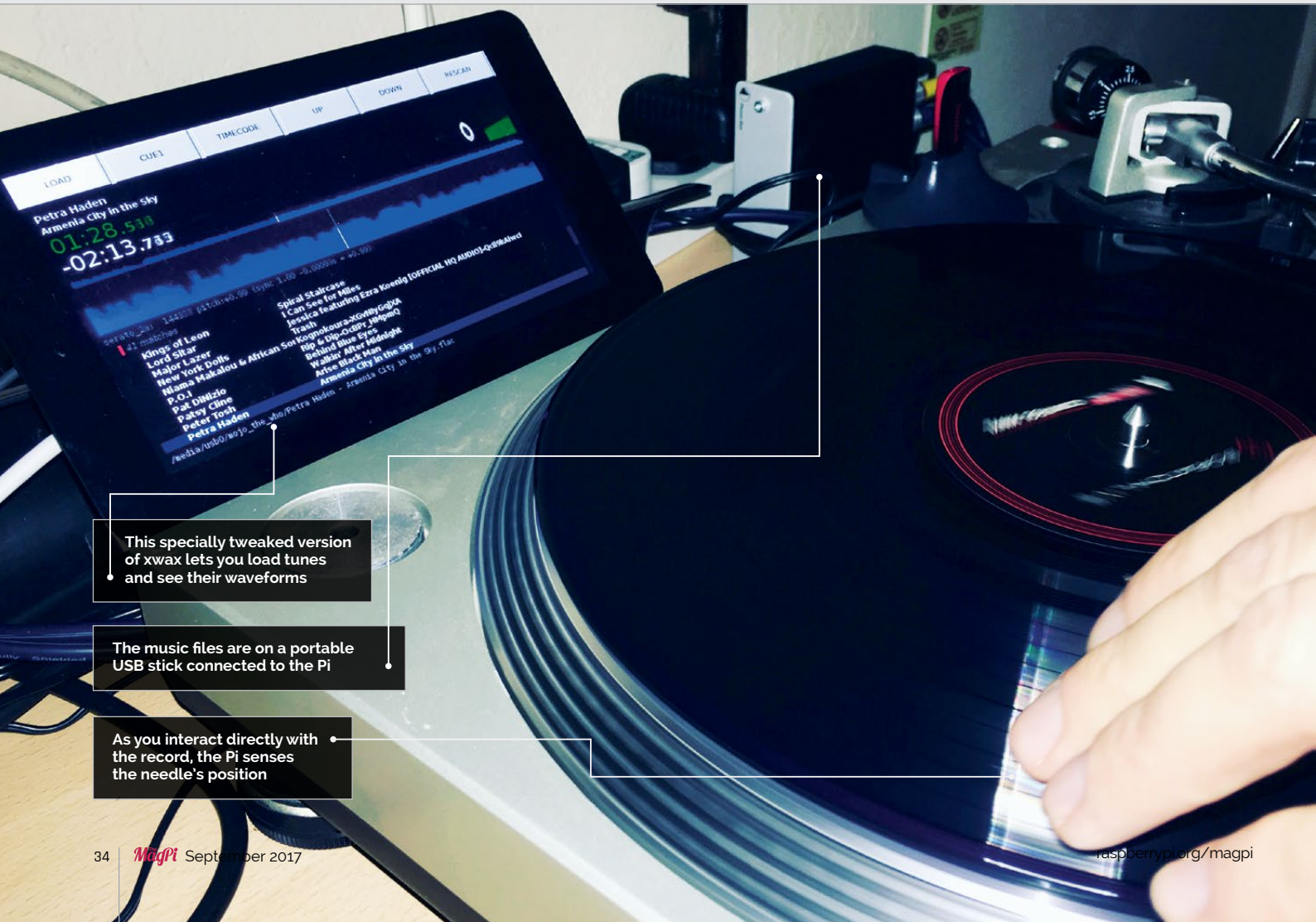
PI DECK

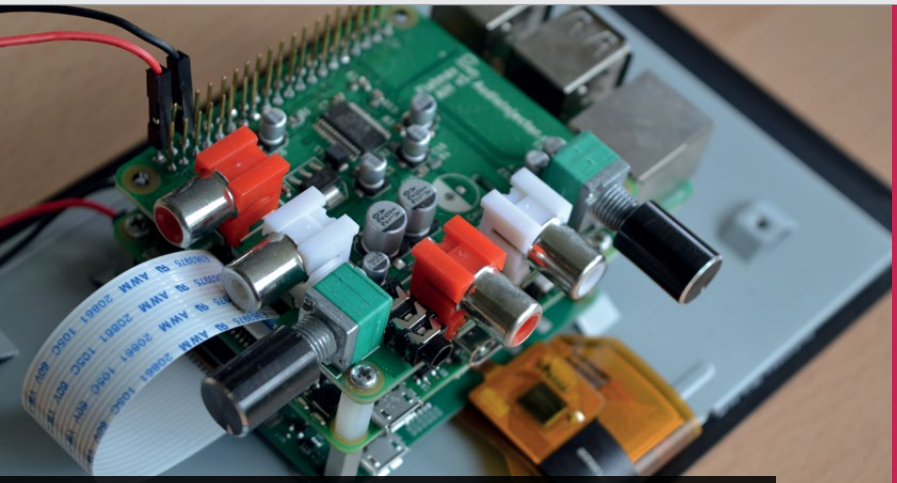
Digital music can't be scratched – or can it? **Daniel James** and **Chris Obbard** go 'old school' with a Pi-based digital vinyl system

Ever since he saw *Breakdance: The Movie* in 1984, Daniel James wanted to be a DJ. But he soon realised scratching expensive vinyl or carting it from venue to venue is far from ideal. "Unless you are famous enough to have a roadie, large boxes of vinyl are heavy and impractical," he tells us. There's also the problem that a lot of music is not being released on analogue vinyl, despite the huge resurgence of interest in the format.

Digital Vinyl Systems (DVS) have long provided an alternative. They allow you to DJ using digital music files and software while letting you benefit from the feel of a turntable. You simply place a special vinyl record on a standard turntable and the system will read the position of the stylus from a timecode. This is used to play back a digital music file at the same point in time – but these systems can be hugely expensive.

Not now. Daniel and his colleague Chris Obbard at 64 Studio put a Raspberry Pi 3 alongside a standard vinyl deck, eliminating the hassle and expense of hooking digital decks to a laptop. They figured that


This specially tweaked version of xwax lets you load tunes and see their waveforms
The music files are on a portable USB stick connected to the Pi
As you interact directly with the record, the Pi senses the needle's position



The Audio Injector stereo sound card adds line-level audio inputs to the Pi

all you need is a USB stick packed with music files. "As long as there is low latency in both directions of travel, you can make effects such as rubbing the kick drum beats, scratching and backspins sound, feel and look realistic," Daniel says.

Motivated by a desire to show that low latency applications could work reliably on small and inexpensive ARM devices such as the Pi, Daniel and Chris got to work. They used xwax (**xwax.org**), an open-source DVS for Linux capable of playing MP3, FLAC, and AAC files, among others. "But because xwax isn't easy for people new to GNU/Linux to set up the system optimally, we created a ready-made Debian image for the Raspberry Pi that is specialised for this one application," reveals Daniel. "It means DJs don't have to go through as many steps to get it running."

> "Most of the setup is done with shell script, which is easy to hack"

The pair had tested Raspbian images and various kernels with hand-soldered audio hardware to create the inputs and outputs that they needed. "Then we tried a HAT sound card from **audioinjector.net** and some USB audio interfaces which include phono cartridge preamplifiers. These are needed because the stylus on the record outputs a signal at a very low level, compared to other audio devices."

The greatest challenge was getting the audio interfaces to work with low latency since many of the known techniques are for PC architecture. "Interrupt tweaking doesn't work the same way on the ARM architecture, for instance," Daniel explains, "but switching to newer Linux kernels helped a lot." The majority of the work involved configuring and scripting various programs to work smoothly together with minimal user input. "Most of the setup is done with shell script, which is easy to hack."

A screen completed the package. Daniel and Chris decided to use the official Raspberry Pi seven-inch touchscreen. "We wanted something that would be easy to set up," Daniel continues, "but the Pi Deck works with any compatible screen. If you're not using a touchscreen, an ordinary mouse can be used to click the buttons. A QWERTY keyboard is useful for searching music titles."

Since creating the Pi Deck last October, the pair have been excited at the level of positive feedback. Hearing about people using it across the world has been music to their ears. "People appreciate the low latency and stability," Daniel concludes. "These are the crucial factors for any performance."

HEY, MR DJ

>STEP-01
Put the record on

Once Pi Deck is set up, place a control vinyl on the turntable, power up the Pi, and insert the USB stick. Waxed paper under a felt slipmat will reduce friction.

>STEP-02
Position the stylus

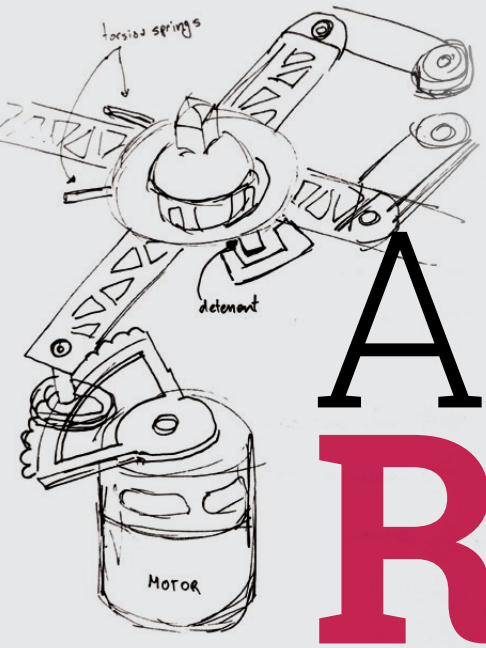
Put the stylus on the control vinyl and use your hand movements to find the first beat of the record. Cue this via the mixer headphones or the waveform display in xwax.

>STEP-03
Scratch away

From this point on, the control works just like an analogue vinyl record. You can back-cue and scratch the vinyl, for instance, pushing the record forward or in reverse.

ALONSO MARTINEZ

Working as a Technical Director for Pixar, taking his experience in character creation into his exploration of interactive robots.
twitter.com/alonsorobots



ALONSO'S ROBOTS

Alonso Martinez explores the ideas of interaction and individuality in robots, creating adorable Raspberry Pi–based characters that play and learn

Quick Facts

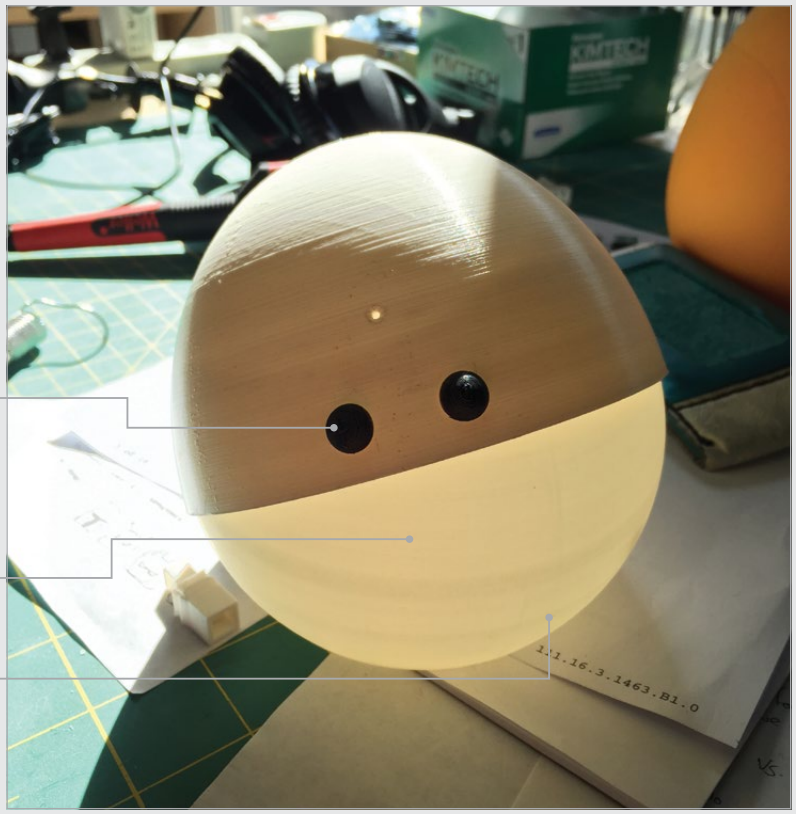
- Alonso learnt the majority of his maker skills from internet videos
- Mira went through multiple designs before her final egg shape
- She charges via a small port on her base
- Mira's small on-board camera can utilise face recognition
- Alonso's next build, Lumens, doubles as a night light

An animator by trade, Alonso Martinez wanted to take his maker skills to the next level. He decided to explore the idea of interactivity with robot characters by creating Gertie, Mira and Lumens.

With Gertie, he was able to explore the idea of the ball bounce – a staple in animation school, where students are asked to animate a ball, and the reaction of its surface when it connects with another object. Where Gertie excelled at bouncing, there was still a lack of the emotion and personality that Alonso hoped to achieve.

Mesmerising Mira

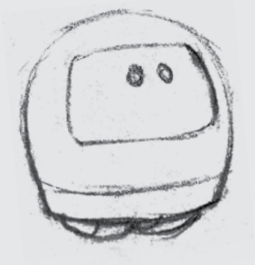
Enter Mira. Alonso wanted to create a character that was not only aesthetically pleasing and highly interactive, but also able to explore the science behind how we perceive a character based on its shape and features. Mira's round form is the result of a study into shape science. Her lack of limbs and sharp edges creates an instantly accessible and pleasing character. And her eyes, with their mini LED screens that blink with their deep, somewhat galactic blue orbs, draw us to her that little bit more.

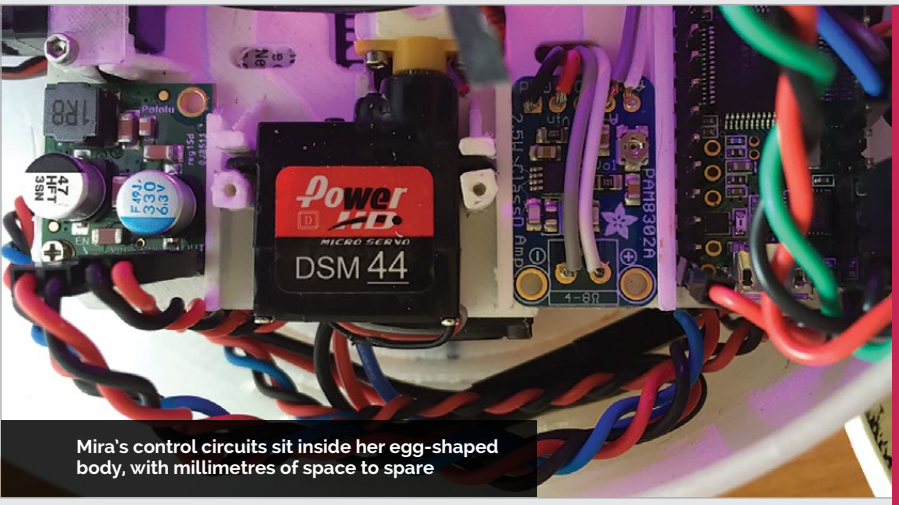


Mira's blinking eyes are powered by two small LCD screens that run constant animations

Her shape is the result of an exploration into shape science, and how we perceive certain features

Mira's recent appearance on the YouTube Tested channel attracted a storm of people desperate to buy their own Mira





Mira's control circuits sit inside her egg-shaped body, with millimetres of space to spare

But Mira is more than just a pretty face. Inside her body lies a Raspberry Pi, laden with code. Cover your face, for example, and Mira will recognise the game of peekaboo via her on-board camera, offering up a shocked squeal of excitement when you say "Boo!" and reveal yourself. Sit Mira beside you at a piano and she'll sing back to you any note that you play, shaking her head like a bird from a classic Disney movie. And while all this interaction is fun and pleasing, Alonso is planning to take the build further.

> "Her lack of limbs and sharp edges creates an instantly accessible and pleasing character"

Robotic evolution

Alonso wants to explore the idea of code evolution through interaction and play. While it's cute to play with Mira – or her successor Lumens, a mushroom-shaped light that hides under its cap – what if she could do more with the information received? What if, through the unique individuality of the user, the robot created its own, similarly unique personality? While explaining the concept, Alonso touches on Conway's Game of Life and the concept of cellular automation with code. Could Mira and Lumens build their own code and truly create their own unique identities?

Millimetre-perfect

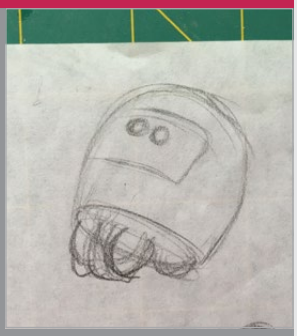
Stepping back from the mind-blowing concepts of interactive, intelligent robots, the physical build behind Mira and Lumens is equally impressive. As an animator, Alonso is highly skilled in 3D design using the computer animation software, Maya. And it was through Maya that Alonso sculpted his robots, enabling him to recreate the Raspberry Pi and components, and measure his 3D prints to the millimetre. Those blinking eyes that give Mira so much personality come from two ultra-thin screens that slip between the two layers of her body. The space was so tight that Alonso found himself having to sand down solder just to make them fit. And as for the way her 'head' moves over several axes? He took the idea of the joystick he'd used as a child to play games and recreated the function using 3D-designed and printed parts.

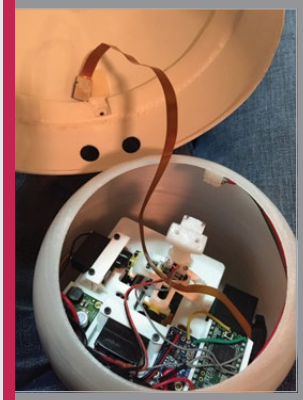
Mira and her growing family are constantly evolving, and we look forward to seeing how Lumens takes shape moving forward. Hands up who wants their own?

BRINGING MIRA TO LIFE

>STEP-01
Design

Mira went through multiple designs during the process of her conception, each variation collected as doodles by Alonso.



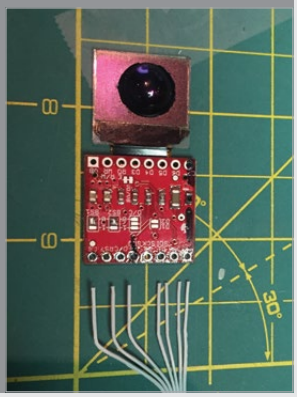


>STEP-02
The bare bones

Each wire and component has its place inside Mira, with no space to spare. Given what's under the hood, Mira's small size is an incredible feat of design.

>STEP-03
Those eyes

Mira's blinking eyes sit within the few millimetres of space between her head and body. The small LEDs are covered with acrylic domes that add a layer of depth to her gaze.



With his latest creation, Lumens, Alonso aims to incorporate the function of a night light into the robot, while maintaining the ideas behind Mira

EDIT TEXT DOCUMENTS PROPERLY

Editing text documents is a vital skill to learn when using a Raspberry Pi

You'll Need

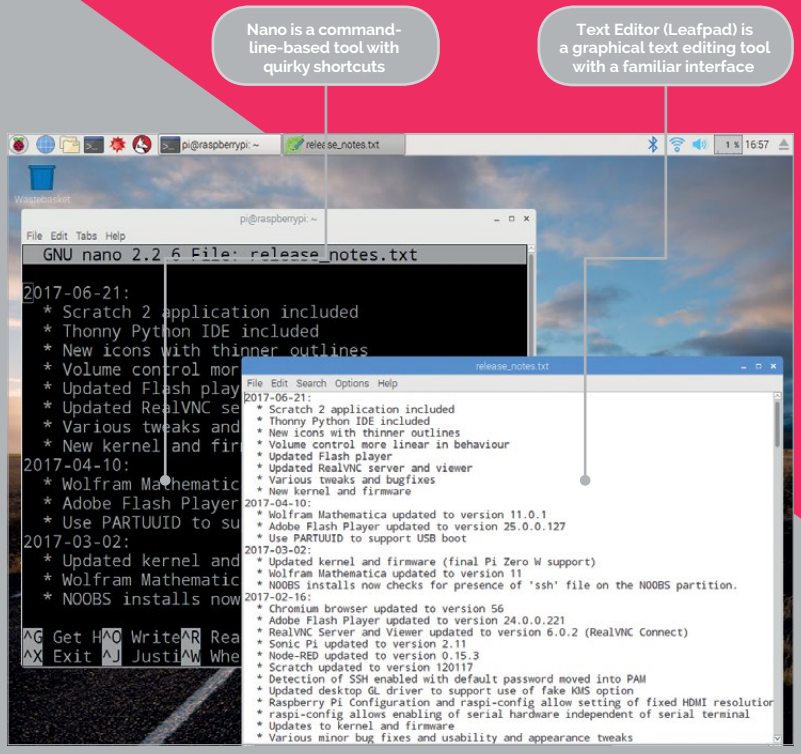
- Raspberry Pi
- Raspbian OS

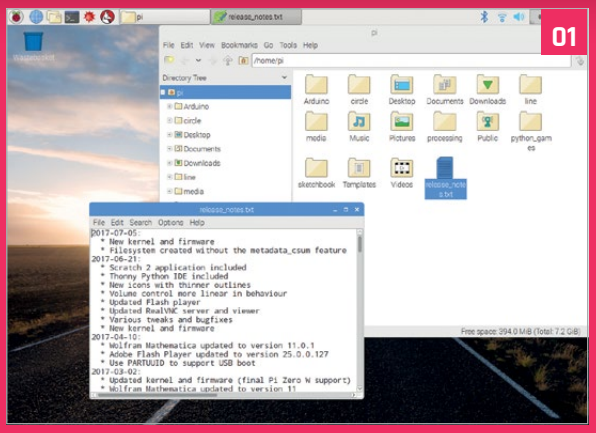
A secret that most computer makers don't tell you is that underneath all the gloss and shine of modern operating systems, it's all text. Every menu, every button, and every setting of every program started as a text document somewhere.

In Raspbian, which is based on Debian Linux, you are far more likely to need to edit text files than on computers running MacOS or Windows. This is a great thing. It lets you get under the hood and really see what's going on.

You may remember the days when computers had text-based interfaces, or you may have only pushed buttons and tapped icons until now. No matter – you will now need to edit text.

There are a lot of different ways to edit text, and everybody has their own favourites. Here were going to look at the two main options: Text Editor (also called Leafpad) and Nano.

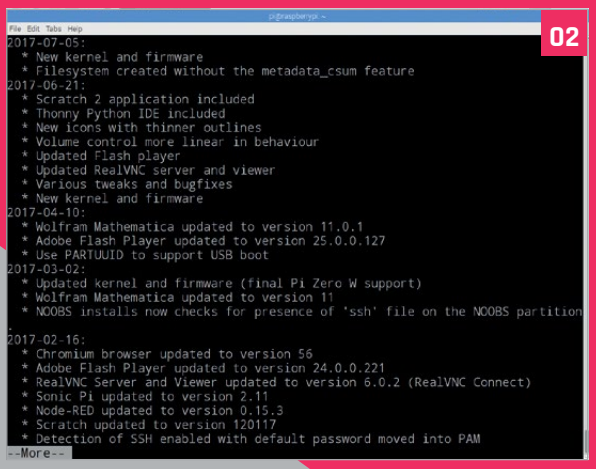

Nano is a command-line-based tool with quirky shortcuts
Text Editor (Leafpad) is a graphical text editing tool with a familiar interface
GNU nano 2.2.6 File: release_notes.txt
2017-06-21:
* Scratch 2 application included
* Thonny Python IDE included
* New icons with thinner outlines
2017-04-10:
* Wolfram Mathematica updated to version 11.0.1
* Adobe Flash Player updated to version 25.0.0.127
* Use PARTUUID to support USB boot
2017-03-02:
* Updated kernel and firmware (final Pi Zero W support)
* Wolfram Mathematica updated to version 11
* NOOBS installs now checks for presence of 'ssh' file on the NOOBS partition.
2017-02-16:
* Chromium browser updated to version 56
* Adobe Flash Player updated to version 24.0.0.221
* RealVNC Server and Viewer updated to version 6.0.2 (RealVNC Connect)
* Sonic Pi updated to version 2.11
* Node-RED updated to version 0.15.3
* Scratch updated to version 120117
* Detection of SSH enabled with default password moved into PAM
* Updated desktop GL driver to support use of fake KMS option
* Raspberry Pi Configuration and raspi-config allow setting of fixed HDMI resolution
* raspi-config allows enabling of serial hardware independent of serial terminal
* Updates to kernel and firmware
* Various minor bug fixes and usability and appearance tweaks



HOW TO: EDIT TEXT FILES

>STEP-01
Viewing text

We've downloaded the release notes for the latest version of Raspbian to view and edit. You can get them from **magpi.cc/2ejN6sk**. Right-click and save the file to your Pi folder. Open a Terminal window. Open the File Manager and double-click the **release_notes.txt** file to view it in Text Editor.


02
2017-07-05:
* New kernel and firmware
* Filesystem created without the metadata_csum feature
2017-06-21:
* Scratch 2 application included
* Thonny Python IDE included
* New icons with thinner outlines
* Volume control more linear in behaviour
* Updated Flash player
* Updated RealVNC server and viewer
* Various tweaks and bugfixes
* New kernel and firmware
2017-04-10:
* Wolfram Mathematica updated to version 11.0.1
* Adobe Flash Player updated to version 25.0.0.127
* Use PARTUUID to support USB boot
2017-03-02:
* Updated kernel and firmware (final Pi Zero W support)
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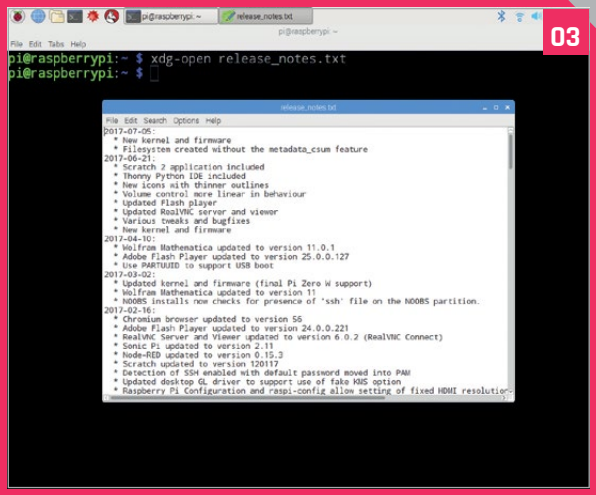
* NOOBS installs now checks for presence of 'ssh' file on the NOOBS partition
2017-02-16:
* Chromium browser updated to version 56
* Adobe Flash Player updated to version 24.0.0.221
* RealVNC Server and Viewer updated to version 6.0.2 (RealVNC Connect)
* Sonic Pi updated to version 2.11
* Node-RED updated to version 0.15.3
* Scratch updated to version 120117
* Detection of SSH enabled with default password moved into PAM
--More--



>STEP-02
Using cat

Often you'll be working with text files from the command line. The way to do this is using **cat** (short for 'concatenate'). Open the Terminal and enter **cat release_notes.txt**. The text will fly up off the top of the screen. To view the text one page at a time, pipe it through **more** and press **SPACE** to move one page at a time.

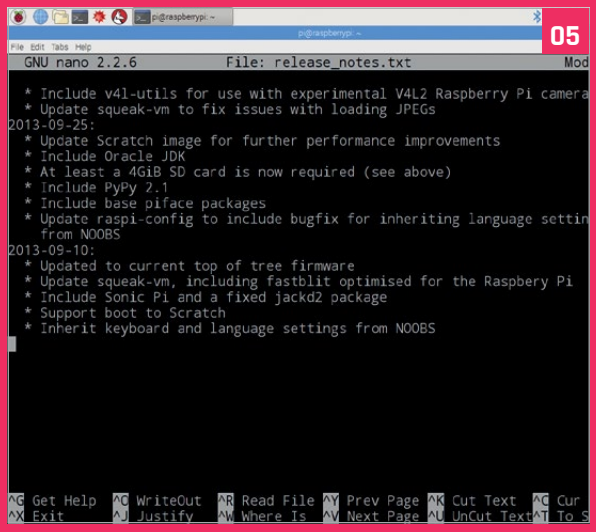
```
cat release_notes.txt | more
```

>STEP-03
Open text

You can open a text file in Text Editor from the command line using **xdg-open** (this will open a file in its default associated app).

```
xdg-open release_notes.txt
```

This is a handy compromise between working on the command line and text editing in a friendly graphical environment. It's the best way to edit text files when you first start.


05
GNU nano 2.2.6 File: release_notes.txt
* Include v4l-utils for use with experimental V4L2 Raspberry Pi camera
* Update squeak-vm to fix issues with loading JPEGs
2013-09-25:
* Update Scratch image for further performance improvements
* Include Oracle JDK
* At least a 4GiB SD card is now required (see above)
* Include PyPy 2.1
* Include base piface packages
* Update raspi-config to include bugfix for inheriting language settin
from NOOBS
2013-09-10:
* Updated to current top of tree firmware
* Update squeak-vm, including fastblit optimised for the Raspbery Pi
* Include Sonic Pi and a fixed jackd2 package
* Support boot to Scratch
* Inherit keyboard and language settings from NOOBS
^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Text^T To S

04
GNU nano 2.2.6 File: release_notes.txt
2017-07-05:
* New kernel and firmware
* Filesystem created without the metadata_csum feature
2017-06-21:
* Scratch 2 application included
* Thonny Python IDE included
* New icons with thinner outlines
* Volume control more linear in behaviour
* Updated Flash player
* Updated RealVNC server and viewer
* Various tweaks and bugfixes
* New kernel and firmware
2017-04-10:
* Wolfram Mathematica updated to version 11.0.1
* Adobe Flash Player updated to version 25.0.0.127
* Use PARTUUID to support USB boot
2017-03-02:
* Updated kernel and firmware (final Pi Zero W support)
* Wolfram Mathematica updated to version 11
* NOOBS installs now checks for presence of 'ssh' file on the NOOBS partiti
2017-02-16:
* Chromium browser updated to version 56
* Adobe Flash Player updated to version 24.0.0.221
* RealVNC Server and Viewer updated to version 6.0.2 (RealVNC Connect)
* Sonic Pi updated to version 2.11
[Read 203 lines]
^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Text^T To Spell

>STEP-04
Nano

You won't always have access to the GUI when working in the command line, and you should quickly learn to edit text files without heading to the GUI. The way to do this is using a text editing app called Nano.

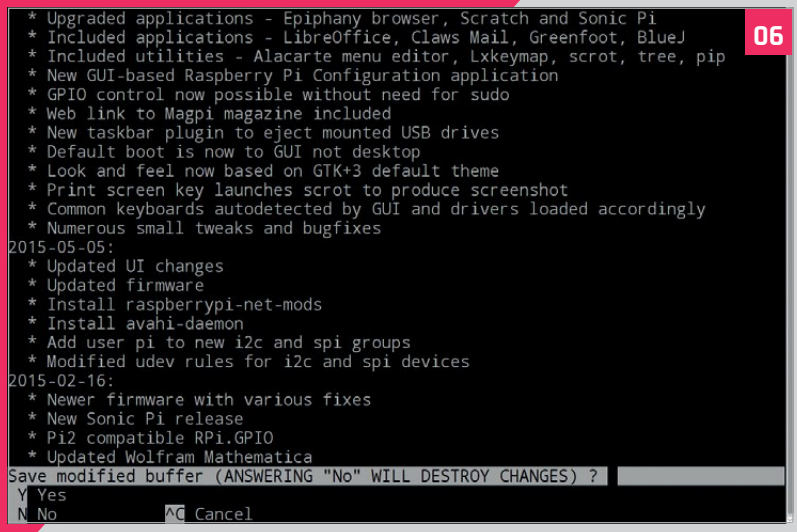
```
nano release_notes.txt
```

>STEP-05
Cut and paste

Nano works just like a word processor – although, without a cursor and interface, you may find it quirky. Move around with the arrows and enter and delete text. You can cut lines of text using **CTRL+K** and paste with **CTRL+U**.

>STEP-06
Save and close

When you've finished editing a text file, you save it using the Writeout function. Press **CTRL+O** and enter **Y** to save the file. Use **CTRL+X** to exit and close Nano and return to the command line.


06
* Upgraded applications - Epiphany browser, Scratch and Sonic Pi
* Included applications - LibreOffice, Claws Mail, Greenfoot, BlueJ
* Included utilities - Alacarte menu editor, Lxkeymap, scrot, tree, pip
* New GUI-based Raspberry Pi Configuration application
* GPIO control now possible without need for sudo
* Web link to Magpi magazine included
* New taskbar plugin to eject mounted USB drives
* Default boot is now to GUI not desktop
* Look and feel now based on GTK+3 default theme
* Print screen key launches scrot to produce screenshot
* Common keyboards autodetected by GUI and drivers loaded accordingly
* Numerous small tweaks and bugfixes
2015-05-05:
* Updated UI changes
* Updated firmware
* Install raspberrypi-net-mods
* Install avahi-daemon
* Add user pi to new i2c and spi groups
* Modified udev rules for i2c and spi devices
2015-02-16:
* Newer firmware with various fixes
* New Sonic Pi release
* Pi2 compatible RPi.GPIO
* Updated Wolfram Mathematica
Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
Y Yes
N No ^C Cancel

UNCOMPRESSING FILES ON A RASPBERRY PI

How to extract just about any file on your Raspberry Pi

You'll Need

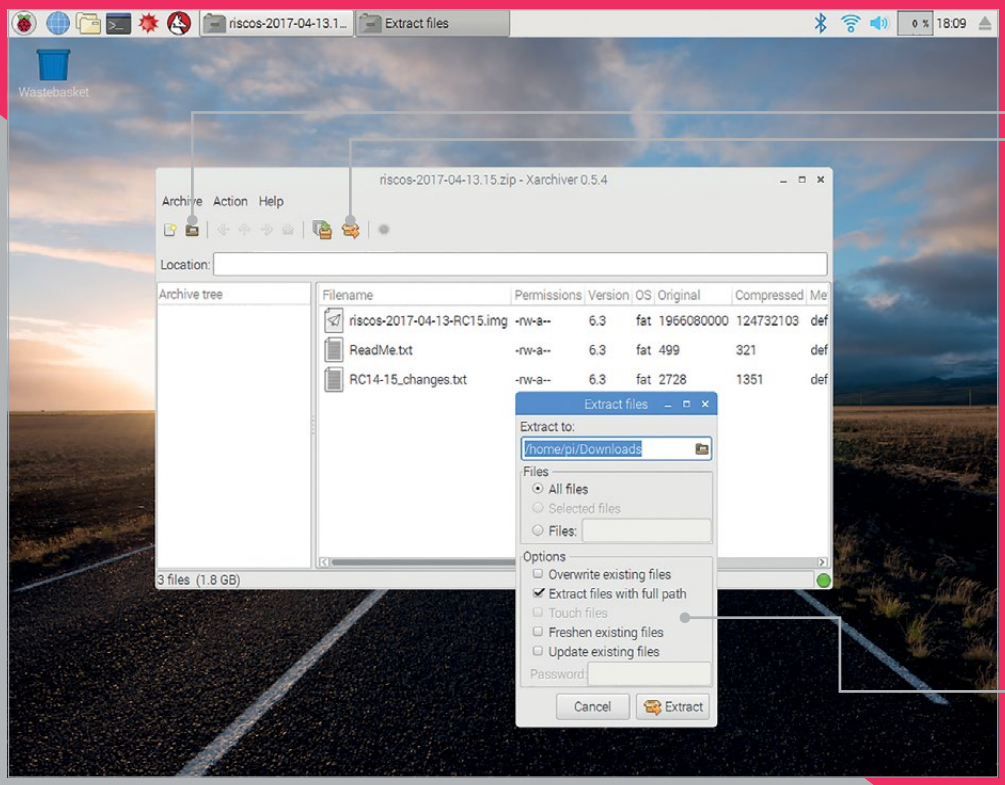
- Raspberry Pi
- Compressed files

Files downloaded from the internet almost always arrive on your computer as compressed files. Files are often compressed before being made available for transfer. The reduced file sizes are quicker to download, smaller to host, and save money on bandwidth.

Pretty much everybody is familiar with the concept of a compressed file, often called a 'zipped' file thanks to the early, and still popular, zip format.

Uncompressing, or 'unzipping' a compressed file isn't a complicated task, but there is a baffling array of different compression techniques and files, each requiring its own tool and technique for restoring the file to its former glory.

In this feature we're going to look at the different compressed file types you'll come across when using a Raspberry Pi, and how to go about unzipping them.

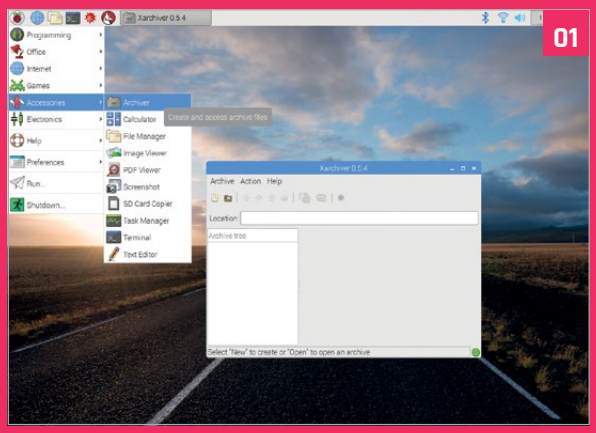


The Open File icon is used to select a compressed file

The Extract Files icon opens a second window with extraction options

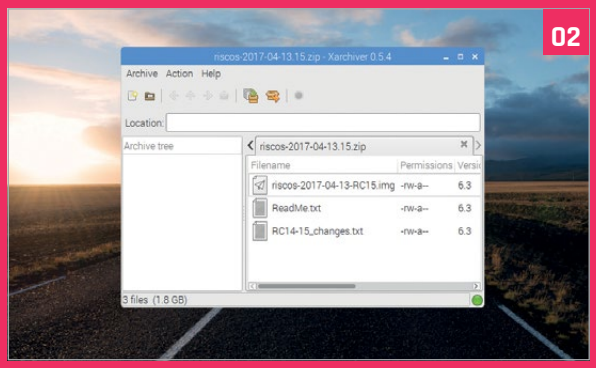
Extract Files is used to select a download location, choose options (including a password), and extract the original files

HOW TO: UNCOMPRESS FILES



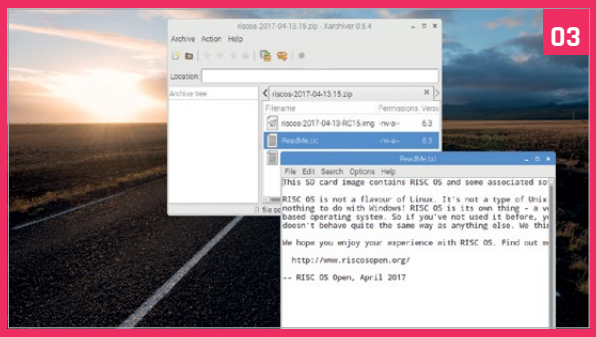
>STEP-01
Archiver

Your first stop for uncompressing any file on your Raspberry Pi should be to use Archiver (**magpi.cc/2wmJWO5**). This lightweight desktop app, also known as Xarchiver, is included with Raspbian and can handle 7-zip, arj, bzip2, gzip, rar, lha, lzma, lzop, deb, rpm, tar, and zip archives. Open it using Menu > Accessories > Archiver.



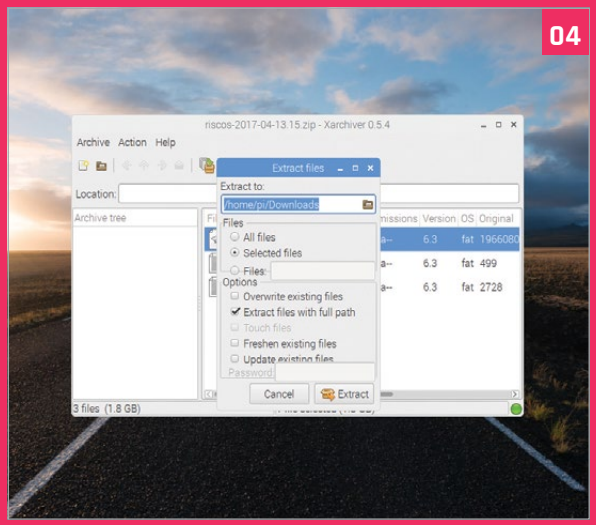
>STEP-02
Open archived files

Choose Archiver > Open or click on the 'Open an Archive' icon. Choose a compressed file (typically it'll be saved in your Downloads folder) and click Open. It may take a while to scan the file, depending on its size. We're using the RISC OS image from here (**magpi.cc/2w2H34Z**) as a test.



>STEP-03
Select and view

Typically, you'll want to extract all the files in a compressed image, but it's worth knowing that you can select individual files and extract them. You can also double-click on files in the compressed image inside Archiver to view them (handy for ReadMe files).



>STEP-04
Extract

The Extract Files window is straightforward. If all you want are the files, then click Extract and they'll be saved into the same location (typically Downloads). You can change the Extract To folder, but you won't have sudo privileges, so stick to directories inside **/home/pi/**. You can also enter the password to access restricted compressed files. The icon in the bottom-right corner of Archiver will flash green and red while it extracts the files, and solid green when it's done.

Terminal

You may need to extract files while working from the command line. There's a range of tools you'll need – some are installed on the Raspberry Pi and others you'll need to acquire with `apt-get`. Here are the commands you need for many popular extension types. Enter `man` and the file type, such as `man tar`, to view more information.

File extension: .tar

```
tar xvf filename.tar
```

File extensions: .tar.gz, .tgz, .tar.bz

```
tar xzvf filename.tar.gz
```

File extension: .gz

```
gunzip filename.gz
```

File extensions: .bz, .bz2

```
bunzip2 filename.bz2
```

File extension: .xz

```
unlzma filename.xz
```

File extension: .zip

```
unzip filename.zip
```

File extension: .7z

```
sudo apt-get install p7zip-full
7z x filename.7z
```

File extension: .rar

```
sudo apt-get install unrar-free
unrar x filename.rar
```

MIKE'S PI BAKERY

MIKE COOK

Veteran magazine author from the old days and writer of the Body Build series. Co-author of *Raspberry Pi for Dummies*, *Raspberry Pi Projects*, and *Raspberry Pi Projects for Dummies*.
magpi.cc/259aT3X

BUILD A POLYRHYTHMIC SEQUENCER

Make great polyrhythmic music, generated by your Pi

You'll Need

- MIDI / USB interface lead
- MIDI sound module (any type)

Back in *The MagPi* #58 we showed you our Hexome simulator, running on a mobile device and controlling a sequence. It used concentric rings of trigger positions, starting with a ring of six with each subsequent ring having six more trigger positions. Now we take that basic idea, run with it, fall over, pick up the pieces, and assemble it into a universal polyrhythmic sequencer.

The basic concepts are the same, but this project gives us nearly unlimited flexibility. Each ring generates only one note, and those notes can be changed by mapping. However, almost everything else has changed. There are up to six rings in the sequence: each ring can have a maximum of 32 trigger positions, and can be individually muted. The big change is that each ring can have its own individual sound and volume, courtesy of MIDI.

MIDI connection

MIDI stands for Musical Interface for Digital Instruments. It is a very old standard, but still as popular as ever. MIDI is a serial interface that sends messages between musical devices, which include instruments (like a keyboard), and sound modules that generate an audio signal. Some devices can combine the two categories in one device – the most popular being sound-generating keyboards. Messages consist of two or three bytes, and cover commands such as Note On and Note Off, as well as other controls, including volume, vibrato, echo, and pitch bend.

A MIDI connection can control 16 different channels, where a channel can range from one voice or sound to a totally separate piece of hardware. Often instruments have a switch that determines the channel they transmit on, and most will default to channel 1.

MIDI runs at the quirky baud rate of 31,250 baud. It is odd by today's standards, but in the old days it was used because it was simple to generate. A MIDI device can have an input and an output, and, much to the surprise of younger people, an input must be connected to an output. There can also be a MIDI 'Thru' ('through' in English), which is simply the

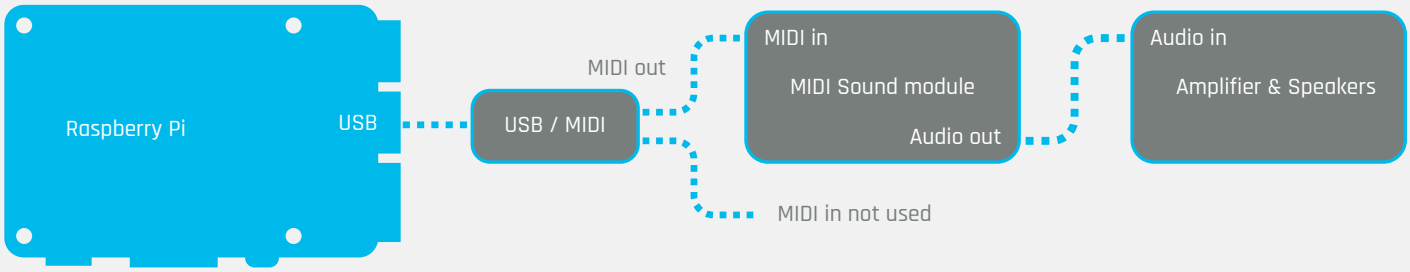
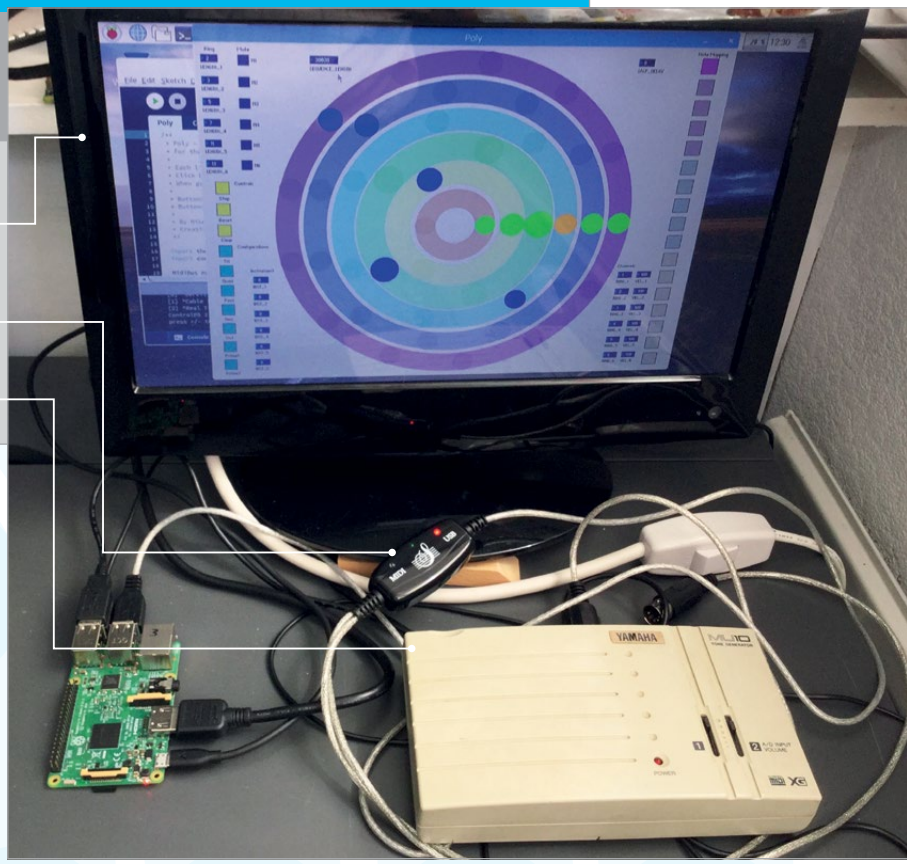


Figure 1 A block diagram of the complete hardware setup


The polyphonic sequencer controls are displayed on the screen
You'll need a USB to MIDI interface box to allow the Pi to talk to the module
This MIDI sound generator module is a Yamaha MU10

signal from an MIDI input, passed to an output, allowing one MIDI output to talk to a number of inputs in a chained fashion.

The quirky baud rate is a historic accident. At the time, you would have used a 1 MHz clock for your processor, which you simply divided by two to give 500 kHz. This was fed directly into the UART (serial chip), which required a clock signal of 16 times the baud rate, giving you 31,250 baud. While the Raspberry Pi can't support that rate directly, it can be helped to do so. Although this was relatively simple on earlier models, the Pi 3 uses the good serial port for Bluetooth, and the second serial port is tied to the clock speed – which can be variable depending on processor demand and temperature. The simplest solution is to bypass the serial port and plug in a USB/MIDI lead. While these used to be expensive, today you can find them for less than £5.

We also chose to use a hardware MIDI sound module for this project. We used the Yamaha MU10, but there are any number of modules that could be used – many available second-hand at bargain prices. There are many other options for this project – see the 'Taking it further' section at the end of this article. The basic setup we used is shown in **Figure 1**.

Why MIDI?

So why use MIDI for this project? Other projects we have worked on involving sound generate that sound by playing samples. Those samples have to be found, recorded and put into the appropriate files. If you want to use more than a handful of different instruments, this is a lot of work. It can also result in an unsatisfactory quality of sound, because you can't control the individual volume, and you can experience audio clipping if too many samples are played at the same time. By using MIDI, we can leave the instrument or voice generation to another piece of hardware or software.

Polyrhythmic sequencer

The original Hexome was based on a hexagonal grid of concentric circles. This gave an inner ring of six positions. Around that was a circle of 12, around that a circle of 18, and so on. This led to a rule that any ring Rn has the number of positions in Rn given by:

```
Rn= Rn-1 + 6
```

...where Rn-1 is the number of keys in the previous ring.

With this software, we can base the rings on any number, so that formula becomes:

```
Rn= Rn-1 + B
```

...where B is the base number of the innermost ring. This leads to the concept of a Triome, based on three positions on a ring – or a Quadome, Pentome, Heptome or Octome. Each of these models can be set up using this software. Additionally, any number of trigger points can be set up on a ring, up to a maximum of 32. For example, if each ring has the same number of trigger points, you have simply produced a conventional N step sequencer.

The length, or number of steps before repeating, of any particular setup is given by the highest common factor of each of the rings. This is maximised in setups where the rings contain a prime number of trigger points, as this gives a sequence length of the number of trigger points in each ring multiplied together. If you start at two triggers for the smallest ring, this gives a staggering 30,030 steps before a repeat. Starting with a base of three you get even more, at 255,255. At these sequence lengths, the result is indistinguishable from random sounds.

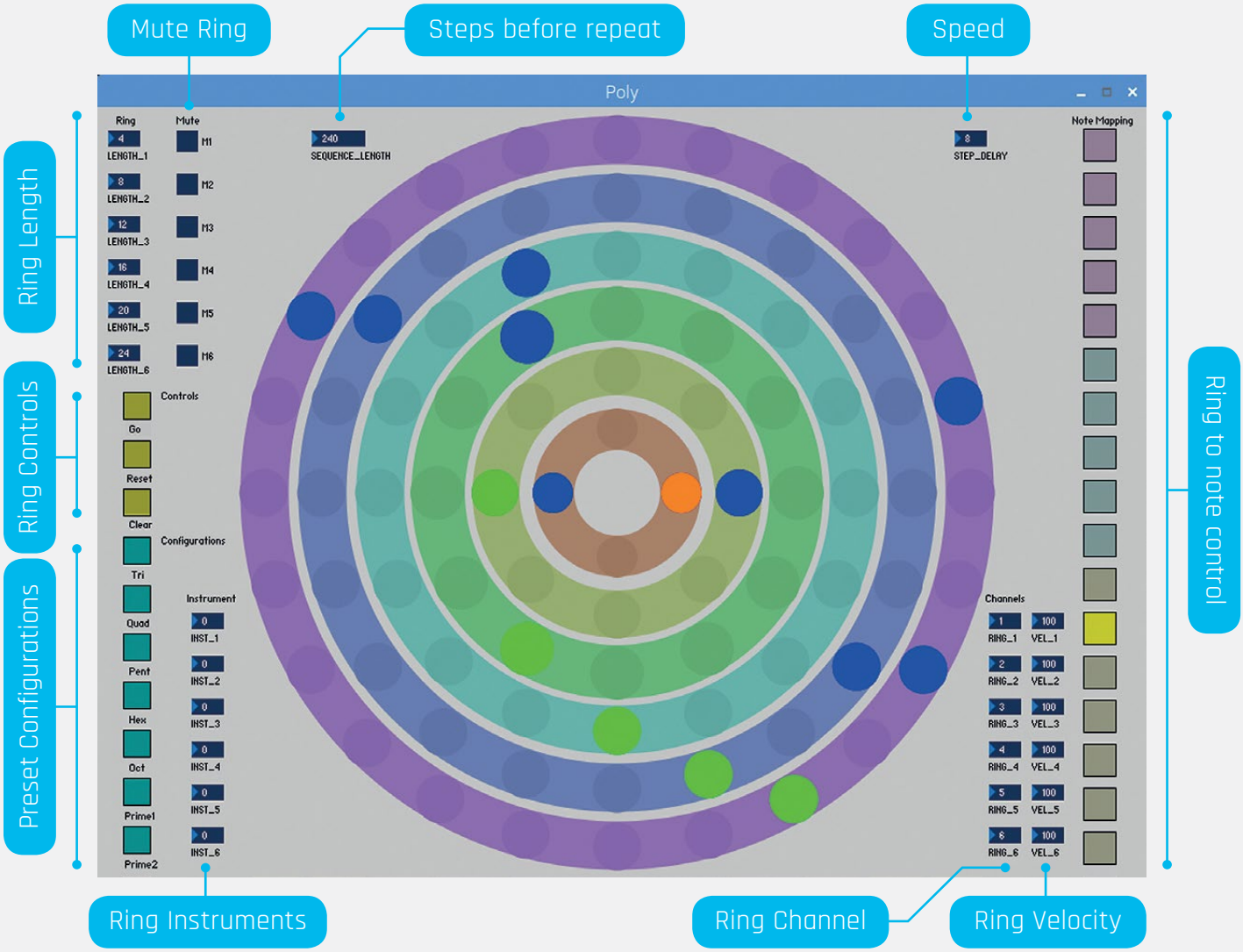


Figure 2 Learn to control the sequencer and make some great music

Implementation

To write the code, we are going to use the Processing language. If you haven't already, install Processing by opening a Terminal window and typing:

```
curl https://processing.org/download/
install-arm.sh | sudo sh
```

You also need to install two libraries. From the Sketch menu, go to the import library entry and choose Add Library, then search for and install **controlP5**. This deals with the variable controls. Then repeat this and install the **themidibus** library. This is the library that will generate and send the MIDI messages.

As the code is rather long, you can download it from **magpi.cc/1NqJjmV**. It is entirely operated from the keyboard or mouse attached to the Pi.

The number of rings is limited to six in this implementation, simply because the resulting 980×720 pixel window is all that will fit on a standard HD screen. If you want a seven-ring sequencer, you would need a window measuring at least 1100×860 pixels. Each ring is limited to a maximum of 32 trigger points, again due to the physical resolution of the screen. This is despite using the trick of changing the ring width depending on the number of trigger points.

The Code

The code is written in three sections, or tabs: these are **Poly**, **Controls**, and **Note_Map**. In the **Poly** tab, the line at the start:

```
MidiBus.list()
```

…lists all the MIDI devices that have been recognised by the computer, both as input and output devices. We are only interested in output devices, and it is likely that you will only have one such device plugged in. If so, the line:

```
MidiBus(this, 0, 1)
```

…which selects the MIDI device to use, will not need to be changed.

Language
>PYTHON

DOWNLOAD:
magpi.cc/1NqJjmV

PROJECT VIDEOS

Check out Mike's Bakery videos at:
magpi.cc/1NqJnTz

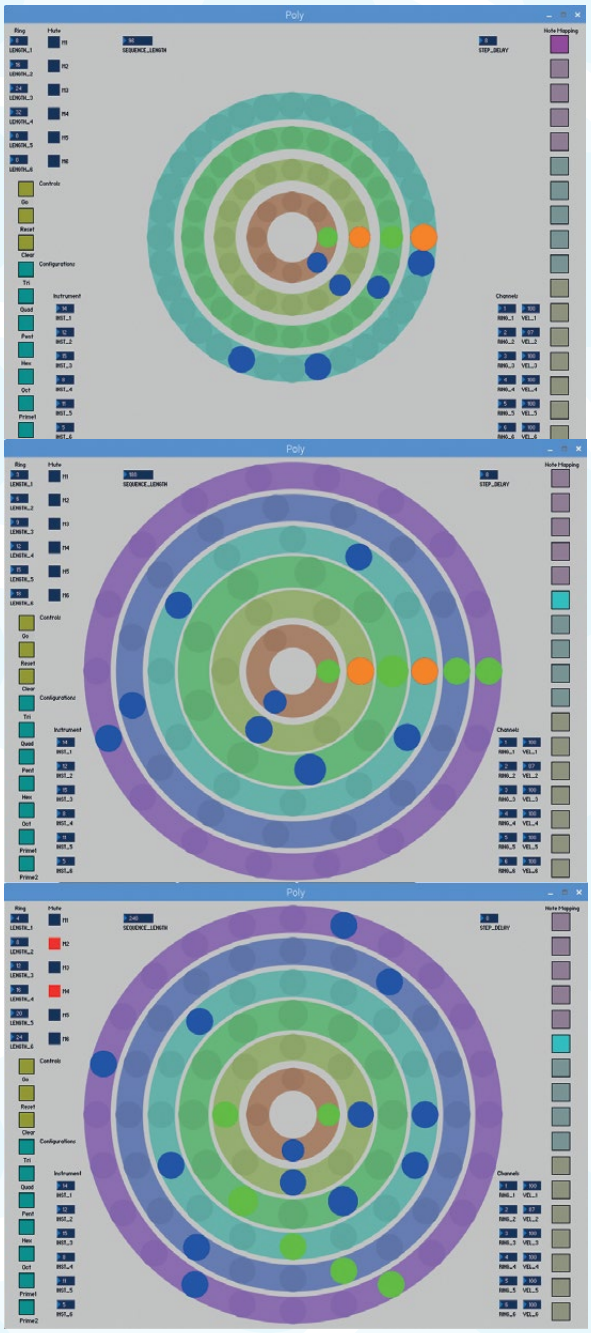


Figure 3 Three different setups for this program

The controls

Figure 2 shows the screen, with an explanation of the controls and what they do. In order to fit round the circles, and to minimise the window width required, the controls are scattered around the outermost circle. Most of the controls need repeating for each ring, including the ring length and mute controls. Others apply to the whole instrument, including the speed control, along with the Stop/Start, Reset and Clear commands.

The configuration controls give you some preset rings and trigger position numbers. These can be modified by the ring length controls, but it is a convenient place to start. The instrument controls determine the voices for each ring. On startup, this is set to 0, which is a Grand Piano. For a list of which instruments correspond to each number, see the implementation sheet for your MIDI sound module.

On the lower right-hand side of the screen is the MIDI channel for each ring. These can be set to the same channel to play all the notes with the same voice. Similarly, the Velocity number determines how hard an instrument is 'struck'. You might like to think of this as a volume control, which in a way it is – but a good sound module will also subtly change the timbre of the sound as the velocity increases.

The note mapping is controlled by the buttons running down the right-hand side of the window. This controls which notes are generated on each ring, as defined in the **Note_Map** code tab. The top five are arranged in thirds, ascending; whereas the next five are in a pentatonic scale. It is a good idea not to change between these in a single piece, as the resulting key change can be jarring. The lower seven mappings are simple single-note shifts in the key of C major. These settings can easily be changed by altering the code in the **Note_Map** code tab. **Figure 3** shows three different setups for the program.

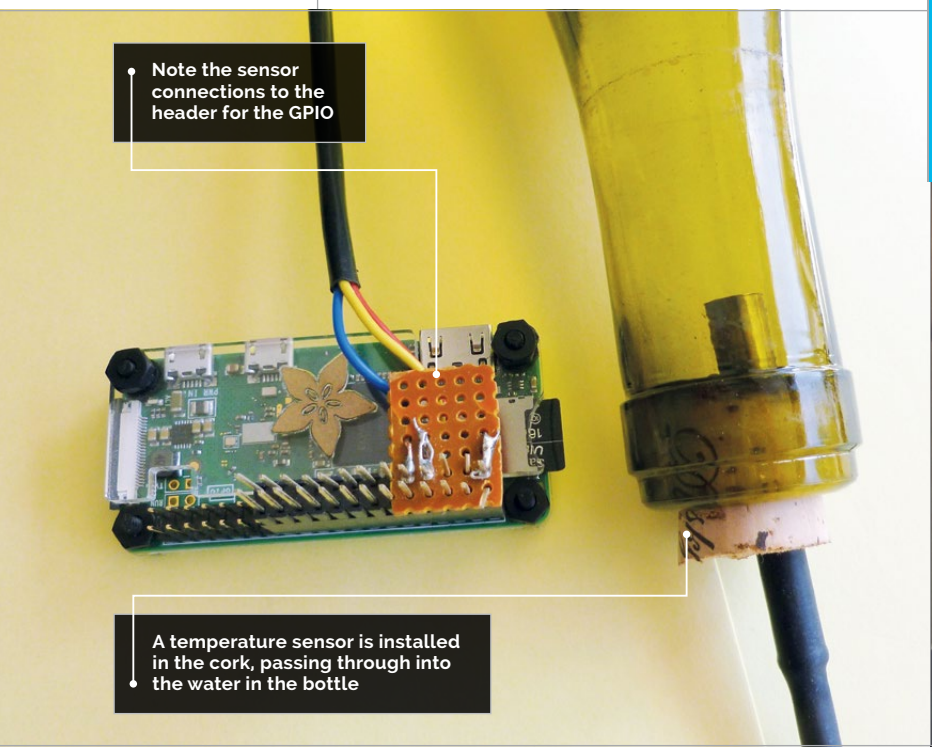
MIDI channel 9

There is something special about MIDI channel 9. When you use this channel, for each note number you don't get a change in note pitch, but a different percussive instrument, including cymbals, drums, cowbells, blocks, and whistles. With the same mapping as the pitched notes, it can be pot luck as to which instrument ends up here.

It is possible that as you change some parameters on the fly, you can be left with a hanging note. This is a note where the sound module has received a Note On message, but no corresponding Note Off message. If you get a hanging note and want to reset it, click the Reset control. This sends Note Off messages to all possible notes on all possible channels, a process which takes less than two seconds.

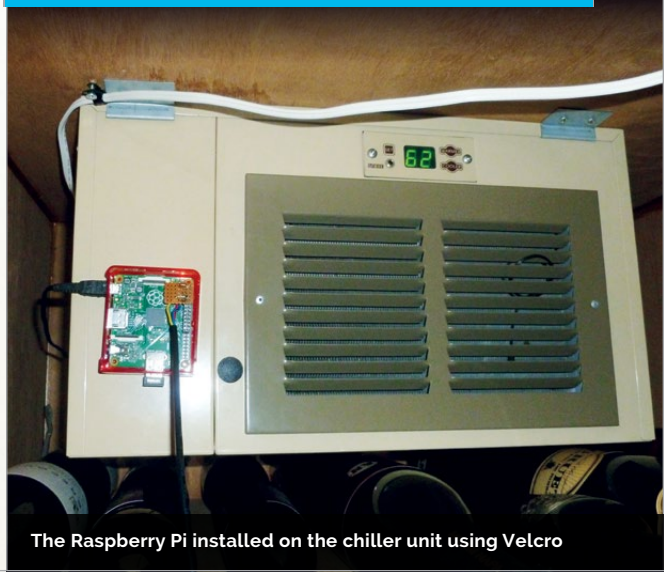
Taking it further

You can extend any program. Despite its flexibility, this one is no exception. The most useful change you could make is to include the ability to save and load the patterns and controls you have created. It is just a matter of saving the appropriate arrays, and restoring them when you load the program. You also might like to have a special set of mapping that kicks in when the percussion channel, channel 9, is selected. You might want to use a soft synth as your sound generator – this could be on another computer, another Pi, or on the same Pi you are using to run the software. The **fluidsynth** and **qsynth** combination is popular on the Pi, but there are several MIDI-capable synthesizers out there. You could even investigate routing the output of this sequencer into Sonic Pi.


Note the sensor connections to the header for the GPIO
A temperature sensor is installed in the cork, passing through into the water in the bottle

BILL BALLARD

Bill is a retired physicist who got back to his programming roots to find fun things to do with his ten Raspberry Pi boards.
github.com/wpballa


The Raspberry Pi installed on the chiller unit using Velcro

WINE SAVER: ROOM TEMPERATURE MONITOR

This project monitors the temperature of a wine storage room hourly, and sends an email when it exceeds an 'alarm' or 'fail' level

You'll Need

- Pi Zero W
- 4GB (or larger) microSD card
- Suitable case for the Pi
- Waterproof DS18B20 temperature sensor
- Stacking header
- Gmail account
- Empty wine bottle and a cork that fits it

We have a wine storage unit in our garage, and over the last 20 years the compressor has failed twice during extreme heatwaves. We weren't constantly checking the temperature display, so we had no warning of the impending failures, which would have allowed us to move the wine to an air-conditioned location and have the compressor repaired. This project provides hourly logging of the temperature, and sends warning emails if the temperature exceeds set limits.

Software setup

Download and install the latest version of Raspbian Jessie Lite on your microSD card. Initialise Raspbian with **`sudo raspi-config`** to the proper international options (time zone, keyboard, wireless country code, etc.), change the default password, and set the host name in advanced options to something like 'wineroom'. Make sure that you enable both SSH and 1-Wire in the **Interface** section of **raspi-config**.

Reboot (otherwise your keyboard settings may not be correct), and set up the wireless by editing the relevant config file: **`sudo nano /etc/wpa_supplicant/wpa_supplicant.conf`**. Add these lines to the end.

```
network={
    ssid="your ssid"
    psk="your password"
    key-mgmt=WPA-PSK
}
```

Be sure to replace **`"your ssid"`** and **`"your password"`** with the actual values for your network, and keep the quotes. Now reboot again.

Use the **`ifconfig`** command to see the IPv4 address that you will need to SSH into the Pi later. Write it down (192.168.1.27 or 10.0.0.27 are typical values). Now you should run the usual update and upgrade to the operating system:

```
sudo apt-get update && sudo apt-get upgrade -y
```

Next, install the mail and ssmtp applications:

```
sudo apt-get install ssmtp heirloom-mailx
```

Edit the ssmtp configuration file to point to your Gmail account as shown. Add the text below to the end

Language
>C AND BASH

DOWNLOAD:
magpi.cc/2uBzlR4

of the configuration file with **sudo nano /etc/ssmtp/ssmtp.conf**.

```
# Wine Room Monitor settings - for gmail
hostname=wineroom
root=your-mail@gmail.com
mailhub=smtp.gmail.com:587
FromLineOverride=YES
AuthUser=your gmail name (leave out the @ and stuff after that)
AuthPass=your gmail password (no quotes needed here)
UseSTARTTLS=YES
UseTLS=YES
AuthUser=LOGIN
```

Now save the file and exit. As we will run the monitor program with **crontab**, we must also change the **/etc/ssmtp/revaliases** file or authentication errors will occur. So, **sudo nano /etc/ssmtp/revaliases** and add the following line:

```
root:your-email@gmail.com:smtp.gmail.com:587
```

Now reboot.

The program

Log back into the Pi. First, create a directory called **wineroom** and move into it:

```
mkdir wineroom
cd wineroom
```

Download the **ds18b20.c** file from GitHub (**magpi.cc/2uBzlR4**) and customise it for your email address and your alarm temperature levels. To compile:

```
gcc ds18b20.c -o ds18b20 -Wall -std=gnu99
```

Hardware setup

Take the wine bottle cork and cut it to half its length with a hacksaw. Carefully clamp it and use a ¼" bit to drill a hole lengthwise through the centre of the cork. Next, push the DS18B20 sensor's stainless steel through the cork so that it is protruding from the other end – this is why we cut it in half. Wetting the sensor may make insertion easier. Now rinse the wine bottle with hot water and fill it nearly full of water. Wet the cork and push it carefully into the bottle, then put the bottle on its side to check for leaks. You may need to add a bit of silicone to seal around the sensor.

On the stacking header, solder a 4.7 kΩ resistor to Pin 1 and Pin 4. Solder the sensor red wire to Pin 1. Solder the white wire to Pin 4; the black wire to Pin 5.

Now plug the header onto the Raspberry Pi (make sure it's off!), being careful to get the location of Pin 1 correct. Boot the Pi up, log in, and test it with:

Place the wine bottle sensor below the top of the rack

```
cd wineroom
sudo ./ds18b20 &
```

Look at the file in your **/home/pi/wineroom** directory called **wine.log**. There should be one entry. You are way over the temperature range and should get an email showing an alarm or alert. This will test whether you've got the email settings correct. If you don't get an email in a few minutes, take a look at **/etc/ssmtp/ssmtp.conf** again to see whether there are any errors.

Now we create a short script to rename the log file and add the year and month to the log file name at the end of every month. Of course, since we run it on the first of the month, we need last month's date. Download **logupdate.sh** from GitHub, edit it to incorporate your email address, then make it executable:

```
chmod +x logupdate.sh
```

Next, we automate things with crontab by editing with **sudo crontab -e** and adding two lines to the end of the file. The first line runs the code at five minutes after the hour, every hour of every day, and the log file renaming happens at four minutes after midnight on the first of the month.

```
5 * * * * /home/pi/wineroom/ds18b20
4 0 1 * * /home/pi/wineroom/logupdate.sh
```

Save the file, then to get the new crontab entries working:

```
sudo service cron start
sudo update-rc.d cron defaults
```

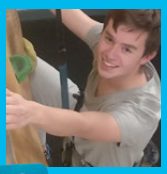
Use some Velcro on the bottom of the Raspberry Pi Zero W case to attach it to the cooler unit. If there is no power plug inside the wine cooler, remove a bit of the sealant around the cooler and run a micro USB power cable through. Then replace the sealant to close the system back up, power it up, and let it run!

CREATE A UNIQUE GMAIL

Create a brand new Gmail account just for this purpose. A unique Gmail account for the wine room prevents a lot of spam.

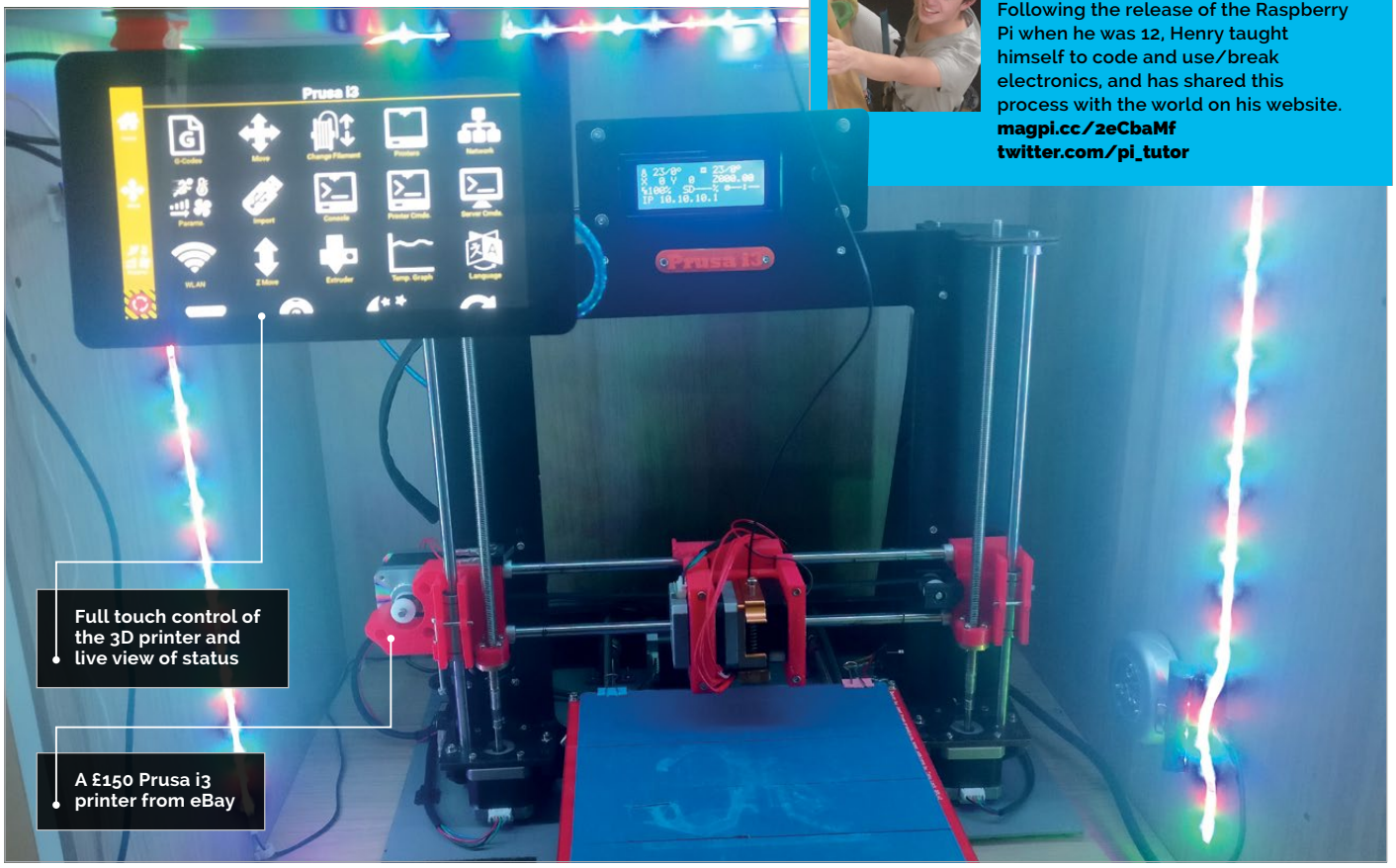
USE BITVISE

Use Bitvise instead of PuTTY (same developers) to check on the temperature at any time.



HENRY BUDDEN

Following the release of the Raspberry Pi when he was 12, Henry taught himself to code and use/break electronics, and has shared this process with the world on his website.
magpi.cc/2eCbaMf
twitter.com/pi_tutor



3D PRINTING WITH YOUR RASPBERRY PI

You'll Need

- 3D printer with updated firmware and USB connection
- Spare microSD card
- WiFi connectivity (USB WiFi dongle if needed)
- Official touchscreen
- Repetier Pro subscription (optional)
- USB webcam (optional)

Climb on board the 3D printing bandwagon on a budget, using a cheap but powerful printer controller with a Raspberry Pi at its core

The rise of 3D printers has seen numerous inexpensive models becoming available in the £100–£150 bracket, but what is the best way to interface with them? A Raspberry Pi, of course! This tutorial will cover the things you need in order to control your already working 3D printer with a Pi, allowing you to have remote access and monitoring capabilities for your printer from anywhere in the world; as well as the ability to start printing, cancel, and tweak the settings mid-print, thanks to our favourite little credit-card-sized computer.

Choosing your printer

If you are not already lucky enough to be the proud owner of a 3D printer, then the first step is to choose one to buy. There are many options on the market, ranging from £100 to upwards of £1,000, with reliability and quality a considerable factor in these price differences. In an attempt to keep the cost of this project low, we opted for a £150 Prusa i3 clone new from eBay. The printer came as a kit and required a few adjustments, along with some Googling due to difficult-to-translate instructions.

Even so, this should be easy enough for a complete 3D printing novice.

There are many of these clones available at a similar price online. If you would prefer a branded budget printer, you can buy a Startt printer for £99 from **imakr.com**. However, it still requires building and adjusting, and has a smaller build volume than the Prusa. For larger amounts of money, the official Prusa 3D printers can be purchased, as well as many others. As this market has grown so rapidly, there are countless options. When buying a 3D printer for use

with a Raspberry Pi, ensure that the printer has a USB interface and that the firmware is recent.

Setting up the software

Once you have built your printer by following the specific instructions, you should be able to print normally, if directly connected to a computer. You'll soon realise that this is a solution with very limited functionality, as you have to be directly connected to the printer in order to make any changes to it.

To set up the software on your Raspberry Pi, head to **magpi.cc/2vBupZw** and download the OS image specified for the Raspberry Pi. Once you have done this, unzip the file and write the image to your microSD card.

If you are using an official touchscreen, connect this to your Pi, as well as a method to connect to a WiFi network if needed. Once the Raspberry Pi is powered on, the touchscreen will display the option to connect to a wireless network, which is vital. Follow the on-screen instructions. If you are not using a touchscreen, you can follow a step-by-step guide to setting up WiFi at **magpi.cc/2vBe739**. Troubleshooting for any problems that may arise while setting up the internet connection and installing the OS can also be found here.

You will then need to set up your printer on the system by inputting the type of printer, as well as its size, shape, and manufacturer. The process is fairly foolproof, and you will be guided through it step-by-step.

Using Repetier software

The majority of the following information will mainly apply to those using the official touchscreen to interface with their printer.

Once the internet connection is set up, you will see a menu similar to the one shown in **Figure 1**. Navigating these menus will allow you to directly control the printer's motors, as well as viewing network settings and sending emergency stop commands. One of the best features of the software is the fact that you can access the printer remotely via the local network by navigating to the Pi's IP address on any device connected to the same LAN. This allows you to upload files to the server to be printed, as well as allowing you to view the progress of prints and cancel them. You can also view a live picture feed of the printer if you connect a USB webcam to the Pi.

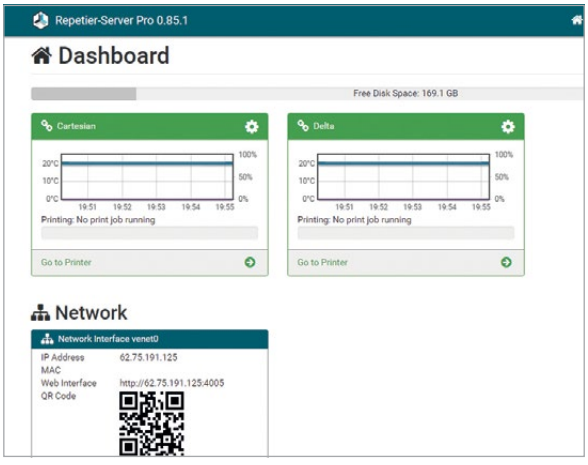


Figure 1 Printer control is also accessible via the internet over a local connection on any device

The screen allows access to the printer's current status, as well as live settings changes and control of the motors

For a better experience, installing Repetier-Host (**magpi.cc/2vBgS4f**) on a PC will offer a more streamlined process that allows you to slice STL files and upload them directly for printing, as well as offering built-in direct control of your printer without the latency introduced by using a web browser.

Printing

As a beginner, it's easy to feel intimidated by all the different file types and methods for printing a predesigned object, but there are several industry-standard methods that are almost always used.

Most 3D designs from online sites such as **thingiverse.com** will be in the form of an STL file that contains the actual shape data of the object. In order to print this design, the file will need to be 'sliced', which converts the shape into exact instructions for the printer's movements. Slicers such as Cura can be found online; however, the Repetier-Host software for PC contains a built-in slicer. By slicing the file, the software will generate instructions for printing based on your printer's exact parameters, including its size and shape. Once the STL file has been sliced, a G-code file will be created, which can be uploaded directly to the printer and run in order to print the object.

LIGHTING

If your printer is in an enclosed space, consider adding some lighting, such as LED strips. This will provide illumination for the webcam, and clearer images for you.

INTERNET CONNECTION

A strong and stable internet connection is required in order to run the printer successfully. If the connection is weak, consider connecting the Pi via Ethernet.

CHRIS BUSH AND DARIA TSAREGORODTSEVA

Chris is a security consultant with one of the world's leading cybersecurity companies, and Daria is a computer science student at Trinity College Dublin.
magpi.cc/2vAZvke

LIVE-CODING ONLINE WITH SONIC PI

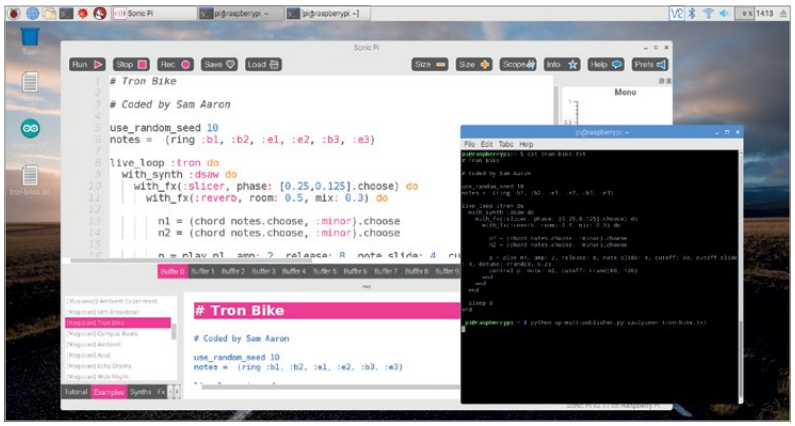
You'll Need

- Paho MQTT Python Client **magpi.cc/2vB4txx**
- Ruby **ruby-lang.org**
- sonic-pi-cli **magpi.cc/2vBhoze**

Share your live-coding performances with listeners anywhere on the internet using Sonic Pi, some simple Python code, and MQTT

Originally created as an interactive and fun instructional tool for teaching both programming and music, Sonic Pi is also a very powerful tool for creating sophisticated live performances as well as algorithmic compositions, all by writing code. It's perfect for people who love to code and love to create music, even if they can't play an instrument. Best of all, Sonic Pi is included in Raspbian, making it easy to get started with coding your own musical creations on your Raspberry Pi. Wouldn't it be great if you could share those creations over the internet? In this project, we'll show you how!

Below Start the publisher to send the Sonic Pi code


Tron Bike
Coded by Sam Aaron
use_random_seed 10
notes = (ring :b1, :b2, :e1, :e2, :b3, :e3)
live_loop :tron do
with_synth :dsaw do
with_fx(:slicer, phase: [0.25,0.125].choose) do
with_fx(:reverb, room: 0.5, mix: 0.3) do
n1 = (chord notes.choose, :minor).choose
n2 = (chord notes.choose, :minor).choose
# Tron Bike
# Coded by Sam Aaron
use_random_seed 10
notes = (ring :b1, :b2, :e1, :e2, :b3, :e3)

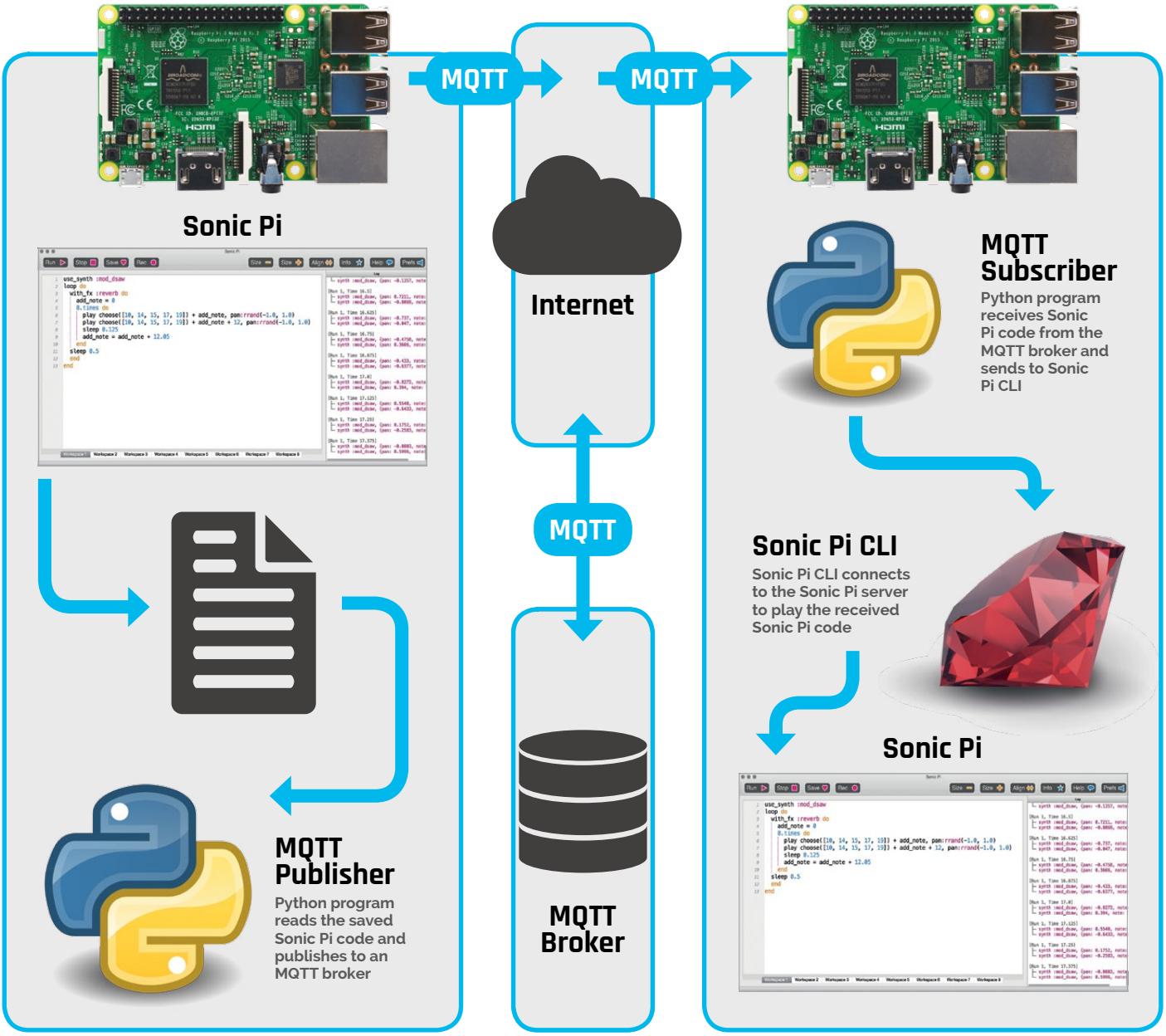
Sharing Sonic Pi compositions

For this project, we will assume that you are at least somewhat familiar with the Sonic Pi GUI and its coding language, and you have at least tried some simple code or played with the many examples included with Sonic Pi. If not, check out the Essentials book, *Code Music with Sonic Pi*, for some excellent beginners tutorials: **magpi.cc/1VGIOux**.

Our goal for this project is to give you a way to go beyond playing your Sonic Pi compositions for whoever happens to be in the room with you. We'll show how you can share your Sonic Pi coding creations with your friends, family, and fans over the internet, so they can listen to your musical masterpieces virtually anywhere in the world.

To do that, we have created a couple of simple Python programs that can interface with Sonic Pi, and communicate with each other over the internet, using a lightweight IoT messaging protocol called MQTT.

MQTT is a publish/subscribe messaging transport protocol (in case you are wondering, MQTT originally stood for MQ Telemetry Transport, but is no longer officially an acronym). It was designed to be very lightweight, simple and easy to implement and is most commonly used for communication in machine-to-machine and Internet of Things applications.


MQTT
MQTT
Sonic Pi
Internet
MQTT Subscriber
Python program receives Sonic Pi code from the MQTT broker and sends to Sonic Pi CLI
MQTT
Sonic Pi CLI
Sonic Pi CLI connects to the Sonic Pi server to play the received Sonic Pi code
Sonic Pi
MQTT Publisher
Python program reads the saved Sonic Pi code and publishes to an MQTT broker
MQTT Broker

The main aspect in the publish/subscribe pattern is the decoupling of publisher and receiver, where the publisher and subscriber don't know about the existence of one another, don't have to run at the same time, and are not halted during publishing or receiving. A third component, a broker, is known by both parties: this filters and distributes all incoming messages by subject/topic.

For this project, we have created two Python programs that use the Eclipse Paho MQTT Python client library to implement an MQTT publisher and subscriber. The programs use the public Eclipse IoT MQTT broker at **iot.eclipse.org** to exchange messages.

The publisher program, **sp-mqtt-publisher.py**, is used to read a file that contains Sonic Pi code, and publish it to the Eclipse IoT MQTT broker. The subscriber program, **sp-mqtt-subscriber.py**, is then used to retrieve the Sonic Pi code from the broker and send it to Sonic Pi for playback.

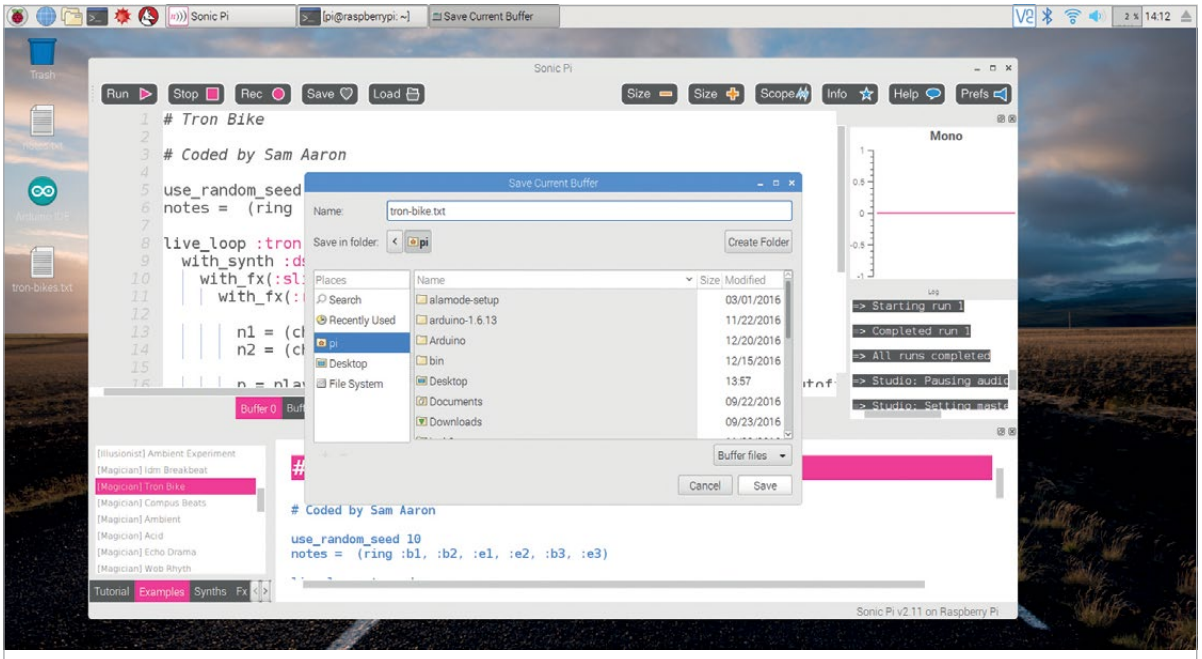
Getting started

To get started, first download the two included Python programs, **sp-mqtt-publisher.py** and **sp-mqtt-subscriber.py**, and save them on your Raspberry Pi.

Next, you will need to install the Python MQTT client library from the Eclipse Paho project. This is easy with the Python package manager, called pip, which is included with Raspbian Jessie. Open a Terminal window on your Raspberry Pi and enter the following command:

```
sudo pip install paho-mqtt
```

Finally, you will need a way to send Sonic Pi code directly to the Sonic Pi synth server, rather than typing it into the Sonic Pi GUI. Currently, there is no built-in capability to play your compositions on Sonic Pi from the command line – although that is apparently planned for Sonic Pi 3. Consequently,



Right Save the composition from the Sonic Pi buffer to a file, so the Python publisher program can read it and publish it to the MQTT broker

we are using **sonic-pi-cli**, written by Nick Johnstone (**magpi.cc/2vBhoze**). This provides a very simple command-line interface, written in Ruby, for interacting with Sonic Pi. Luckily, Ruby also comes as part of the Raspbian Jessie distribution, and **sonic-pi-cli** should work just fine with it. From the Terminal window, enter the following command:

```
sudo gem install sonic-pi-cli
```

> Now it's time to try a simple live-coding performance over the internet

This will install a Ruby script, called **sonic_pi**, in the **/usr/local/bin** directory on your Raspberry Pi, where it can easily be called from the Python code.

Try it out!

Once you have these components installed, it's time to try everything out. First, let's make sure that the **sonic_pi** Ruby program is working. Start by opening Sonic Pi. Once the Sonic Pi GUI is running, open a Terminal window and enter the following command:

```
sonic_pi "sample :loop_breakbeat"
```

You should hear the breakbeat sample loop that is included with Sonic Pi.

With that working, now it's time to try a simple live-coding performance over the internet, using the two Python programs provided. With Sonic Pi open, copy one of the code examples included with Sonic Pi into a buffer. Then, using the Save button, save the buffer to a file. In the screenshot, we have chosen the **tron-bikes** example because, well – who doesn't like the sound of *Tron* light cycles?

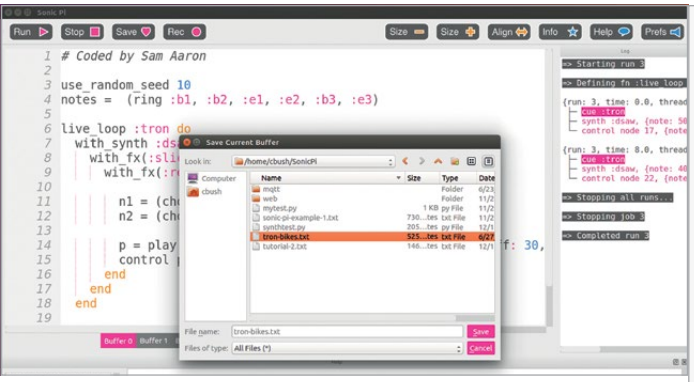
Once the buffer is saved to a file, run the **sp-mqtt-publisher.py** program from a Terminal window. You will need to include two command-line arguments when you run the program. The first specifies the MQTT topic name that you will publish to. Choose something that is simple and likely to be unique. The second argument is the name of the code file in which you saved the buffer from Sonic Pi. For example, you might enter the following command:

```
python sp-mqtt-publisher.py saulpimon
tron-bike.txt
```

The publisher program will read the contents of the code file named on the command line, and publish it to the Eclipse IoT MQTT broker under the provided topic name. The publisher program runs an infinite loop, and every ten seconds will re-publish the code

Language
>PYTHON

DOWNLOAD:
magpi.cc/2vB5FRx



Above The saved file will be published to the MQTT broker

to the MQTT broker. With each iteration of the loop, it will check to see if the code file has been updated and, if so, it will re-read the file before re-publishing, so that the most recent version of the live-coding composition is published to the MQTT broker.

Now, of course, this isn't much of a live-coding performance without listeners, right? If you have a couple of friends who want to help, you can have them install the required components as described in the 'Getting started' section, and run the Python subscriber program, **sp-mqtt-subscriber.py**, to retrieve the published code from the MQTT broker and play it using Sonic Pi on their own Raspberry Pi. Or, if you like, you can run the subscriber program yourself on the same Raspberry Pi that you used to publish the code. To run the subscriber program, first be sure you have installed the Paho MQTT client and the **sonic_pi** Ruby script as described above. Next, open Sonic Pi and run the Python subscriber program, being sure to specify the same topic name that was used with the publisher above as a command-line argument. For example, enter the following command:

```
python sp-mqtt-subscriber.py saulpimon
```

The subscriber program will connect to the Eclipse IoT MQTT broker and retrieve messages that are published to the topic named on the command line. When a message is received, the subscriber program then calls the **sonic_pi** Ruby script, passing the retrieved message as data. The **sonic_pi** Ruby script connects to Sonic Pi and sends it the code, which will then be played. Don't worry when you don't see the retrieved code in the Sonic Pi GUI on the Raspberry Pi on which you're running the subscriber program. The **sonic_pi** Ruby script doesn't interact with the Sonic Pi GUI at all. Instead, it connects directly to the Sonic Pi synth server to send the code.

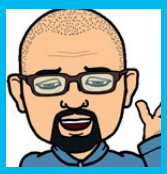
You are now ready to start sharing your live-coding masterpieces over the internet. Simply make changes to the Sonic Pi code as you would with any other live-coding performance, and save the buffer to a file as described above. The simple Python programs and MQTT will handle the rest, for you and your faithful listeners!

rpmqtt-publisher.py

```
import paho.mqtt.client as paho
import time, os, sys

topic = sys.argv[1]
filename = sys.argv[2]

host = "iot.eclipse.org"
client = paho.Client()
client.connect(host, 1883)

timestamp1 =  -10
while True:
    timestamp2 = os.path.getmtime(filename)
    if timestamp1 != timestamp2:
        with open(filename, 'r') as myfile:
            filedata=myfile.read()
        timestamp1 = timestamp2
    client.publish(topic, filedata)
    time.sleep(10)
```

rpmqtt-subscriber.py

```
import paho.mqtt.client as paho
import sys, subprocess

def on_message(client, userdata, message):
    pipe = subprocess.Popen("sonic_pi", stdin=subprocess.
PIPE, shell=True)
    pipe.communicate(input=message.payload)
    print(str(message.payload.decode("UTF-8")))

def on_disconnect(client, userdata, rc):
    subprocess.call("sonic_pi stop", shell=True)

topic = sys.argv[1]
host = "iot.eclipse.org"
client = paho.Client()
client.connect(host, 1883)
client.subscribe(topic, 0)

client.on_message = on_message
client.on_disconnect = on_disconnect

print("Press Ctrl-C to stop...")
try:
    client.loop_forever()
except KeyboardInterrupt:
    client.loop_stop()
    client.disconnect()
```



TIM RICHARDSON
One half of the CamJam and Pi Wars organisation team, and author of the CamJam EduKit worksheets.
twitter.com/Geeky_Tim

PIHUE CONTROL PHILIPS HUE LIGHTS

You'll Need

- Pimoroni Touch pHAT **magpi.cc/2pafoP9**
- Philips Hue Bridge and Lights **magpi.cc/2uBNFsK**
- phue Python library by StudioImaginaire **magpi.cc/2uBWOBF**

Learn how to control Philips Hue lights with a Raspberry Pi and the Pimoroni Touch pHAT

We're all guilty of spending too much time geeking out! GeekyTim is no exception; he spends his time in 'Hut 8' (his log cabin in the garden) tinkering with Raspberry Pis, 3D printing, and laser cutting. His wife complains when she has to come out in the rain to call him in!

After buying some Hue lights, he wondered whether they could be controlled with a Pi. Philips provides APIs, and other Python libraries have been developed to access the Bridge. So, he put them all together and created the PiHue – a Raspberry Pi Zero W with Touch pHAT that his family can use to call him in from play…

Setting up

We start by connecting our Pimoroni Touch pHAT to the Pi, burning the Raspbian Jessie Lite image onto an SD card, booting up, and connecting to the same network that the Hue Bridge is on.

We need to install a few prerequisites before downloading the PiHue code, including Python 3, pip, Git, the **Touch pHAT** library, and the **phue** library that gives us access to the Hue lights from Python:

```
sudo apt-get update
sudo apt-get install python3 python3-pip git
sudo apt-get install python3-touchphat
sudo pip3 install phue
```

Below The PiHue, with Touch pHAT and custom laser-cut cover to show the colour options

Next, we need to download the PiHue code from GitHub:

```
git clone https://github.com/GeekyTim/PiHue
```

The PiHue code is in the **PiHue** directory:

```
cd PiHue
```

Configuring PiHue

Each of the Touch pHAT's six capacitive buttons will have a different function. The Back (left arrow) button turns the lights on and off; four A, B, C and D buttons flash the lights red, yellow, green, and blue respectively; and Enter (right arrow) makes them all bright.

There are two versions of the code:

- **PiHueRoom.py** controls a Room as defined in the Hue app.
- **PiHueLightList.py** controls individual lights in a list.

The Room version works best with a room that contains more than one light, especially if one is coloured and one is dimmable.

We have to edit the code to make some changes for our Hue setup:

- Set the IP address of the Philips Hue: `bridgeip`. We can find this by accessing our router's IP address list or using a network sniffer tool. The Bridge's MAC address can be found in the Hue app.
- For **PiHueRoom.py**, set the name of the room to be controlled: `roomname`.
- For **PiHueLightList.py**, change the names of the lights in the Python list: `lights`.

Optionally, we can change the list of Hue **xy** colours by adding to those already listed under the comment `# Hue 'xy'` colours.

Language
>PYTHON 3

NAME:
PiHueRoom.py
PiHueLightList.py

DOWNLOAD:
magpi.cc/2vBxtol

Above It's alive!

We can also change the **alert** patterns in the section following **# Alert Patterns**. These are Python lists; the first number is how many times to repeat the pattern. The second is the delay between changes – the recommended minimum delay is 0.4 (seconds).

The remaining values are Python dictionaries of the light status changes.

Use any valid Hue status, e.g. **on**, **bri**, **xy**, **ct**, **sat**, **hue**, **transformationtime** (see the Hue API for details: **magpi.cc/2vEpXfH**).

Dimmable lights do not accept any of the colour changes (**xy**, **ct**, **sat**, **hue**), so just change their brightness instead.

We can specify as many changes as we want.

For Light Lists, the status changes are Python dictionaries that contain the changes for each light type (e.g. **Extended color light** and **Dimmable light**). Other light types can be added if you have them (e.g. **Color Light**, **Color Temperature Light**).

There is one special dictionary that is used by the Touch pHAT's Enter button to set all lights to bright white: **allwhite**. We could redefine this to be a preferred colour and brightness.

Running the code

The line **# b.connect()** must be uncommented the first time the code is run. Just before running it, we must press the Bridge connect button. Run with:

```
python3 PiHueRoom.py
```

…or:

```
python3 PiHueLightList.py
```

The Pi should connect to the Bridge and save the Bridge details in the file **/home/pi/.python_hue**. If we ever need to change the Bridge, we just need to delete this file. We can now re-comment the **b.connect()** line by adding **#** at the front..

Running on boot

There are a few ways to run Python code when the Raspberry Pi boots. A good method is to use **systemd**. In this case, we need to create a configuration file (aka a 'unit' file) that defines a new **systemd** service:

```
sudo nano /lib/systemd/system/PiHue.service
```

…and type in the following (replacing **PiHueRoom.py** with **PiHueLightList.py** if required):

```
[Unit]
Description=PiHue Service
After=multi-user.target

[Service]
Type=idle
User=pi
Restart=always
ExecStart=/usr/bin/python3 /home/pi/PiHue/
PiHueRoom.py

[Install]
WantedBy=multi-user.target
```

Exit and save using **CTRL+X**, **Y**, then **ENTER**.

The permission of the unit file needs to be set to 644:

```
sudo chmod 644 /lib/systemd/system/PiHue.
service
```

We need to instruct **systemd** to start the service during the boot sequence:

```
sudo systemctl daemon-reload
sudo systemctl enable PiHue.service
```

When we reboot the Pi, the PiHue service should run.

Check service status

We can check the status of the PiHue service using:

```
sudo systemctl status PiHue.service
```

The last line should look like:

```
Jul 10 23:26:52 PiHue systemd[1]: Started
Start the Touch pHAT Hue controller.
```

Sometimes the Raspberry Pi disconnects from the network, especially when using WiFi. Once disconnected, it will remain disconnected unless the interface is restarted or the Pi is rebooted. That makes this light switch a bit useless. But help is at hand: we can reboot the Pi if it cannot see your home router!

Follow the instructions by Thijs Bernolet on his blog to enable reboot on network loss: **magpi.cc/2uCoiny**.

CONTROL YOUR OWN WORLD!

Don't just use the code as is – why not experiment and make your lights match your own colour schemes?

LIGHT CHANGES

For rooms with both dimmable and coloured lights, alter the brightness as well as the colour of the room.

FREQUENTLY ASKED QUESTIONS

NEED A PROBLEM SOLVED?

Email **magpi@raspberrypi.org** or find us on **raspberrypi.org/forums** to feature in a future issue.

Your technical hardware and software problems solved...

USING RASPBERRY PIS WITH OTHER DEVICES

WHAT COMPUTERS DOES RASPBERRY PI WORK WITH?

PCs

The Raspberry Pi plays well with PCs (running Windows or Linux) and Macs in the same way any other computer would – you can set it up to view folders and files over the network, and it can read all the files from a PC as long as it is running compatible software.

Smartphones and tablets

Depending on your device, you should be able to connect it to the Raspberry Pi to view the contents of its storage, in the same way that you would plug the device into a PC. Internet tethering over USB can also work, but you will need to look up the specific guides for your devices.

Other Raspberry Pis

As the Raspberry Pi is a fully functional computer, it will interact with another Pi in the same way it would interact with a PC or Mac. Many people use multiple Raspberry Pis in media setups in their homes, with one Pi hosting media files while another Pi plays them on a TV or speakers.

DOES THE RASPBERRY PI WORK WITH MICROCONTROLLERS?

What is a microcontroller?

A microcontroller is a small piece of electronics that, while limited in its function, can be powerful enough to control lights, motors and so on with a bit of programming. The benefit of a microcontroller over a Raspberry Pi is that they typically require less power to run.

Arduino

Popular tools for creating very small computerised projects, Arduinos are cheap and usually use a lot less power than a Raspberry Pi. You can find HATs and another add-ons that enable you to connect a Raspberry Pi with, and even program, an Arduino.

Skip the microcontroller

If power isn't a problem for you, you can usually perform the tasks a microcontroller could do using the Raspberry Pi. There's a huge range of HATs and other Pi add-ons that offer extra functionality, such as motor control, environment sensing, and even higher-quality audio output.

HOW CAN THE PI BE USED TO HACK OR MODIFY OTHER ELECTRONIC PRODUCTS?

Controlling electronics

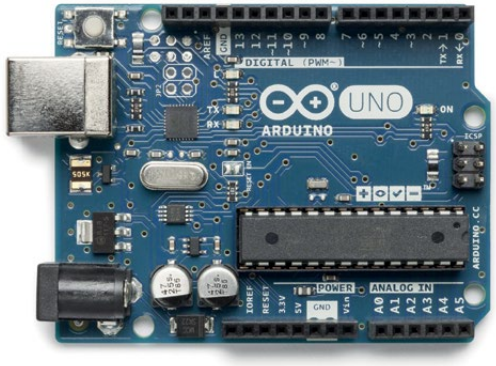
The Raspberry Pi on its own can control other electronic items if you wire them up correctly to the GPIO pins. The most basic function is to sense and send on and off signals, which could be used to control a game using the buttons on an old video game controller.

Correct components

Not every project can be made using the Raspberry Pi on its own. You may need to use components such as thermometers, microphones, light sensors, and analogue-to-digital converters.

Be careful!

Hacking an existing product may not always work – in fact, you may break it or the Raspberry Pi beyond repair! Make sure you've fully researched your project and looked up guides and instructions for similar projects before starting yours.



Above Raspberry Pi can play nicely with microcontrollers

FROM THE RASPBERRY PI FAQ
RASPBERRYPI.ORG/HELP

WHAT ARE THE DIFFERENCES BETWEEN MODELS?

The Model A+ has 512MB RAM (as of August 2016: earlier models have 256MB), one USB port, 40 GPIO pins, and no Ethernet port. The Model B+ has 512MB RAM, four USB ports, 40 GPIO pins, and one Ethernet port.

The B+ was superseded by the Pi 2 Model B. The Pi 2 originally used a 900MHz quad-core ARM Cortex-A7 CPU with 1GB RAM. Some recent versions of the Pi 2 (v1.2) now use a 900MHz ARM Cortex-A53 CPU.

The Pi 3 Model B was launched in February 2016. It uses a 1.2GHz 64-bit quad-core ARM Cortex-A53 CPU, has 1GB RAM, integrated 802.11n wireless LAN, and Bluetooth 4.1.

The Pi Zero and Pi Zero W are half the size of a Model A+, with a 1GHz single-core CPU and 512MB RAM, mini-HDMI and USB On-The-Go ports, and a camera connector. The Pi Zero W also has integrated 802.11n wireless LAN and Bluetooth 4.1.

Product	SoC	Speed	RAM	USB Ports	Ethernet	Wireless/ Bluetooth
Raspberry Pi Model A+	BCM2835	700MHz	512MB	1	No	No
Raspberry Pi Model B+	BCM2835	700MHz	512MB	4	Yes	No
Raspberry Pi 2 Model B	BCM2836 or BCM2837	900MHz	1GB	4	Yes	No
Raspberry Pi 3 Model B	BCM2837	1200MHz	1GB	4	Yes	Yes
Raspberry Pi Zero	BCM2835	1000MHz	512MB	1	No	No
Raspberry Pi Zero W	BCM2835	1000MHz	512MB	1	No	Yes

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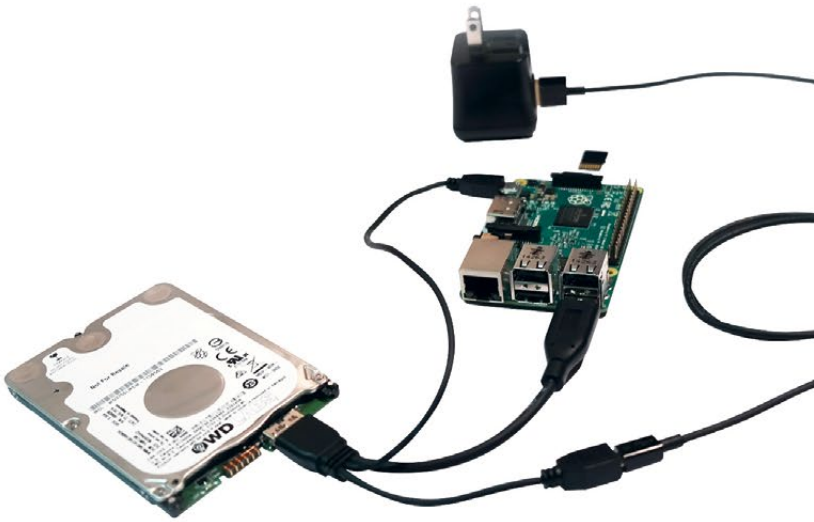

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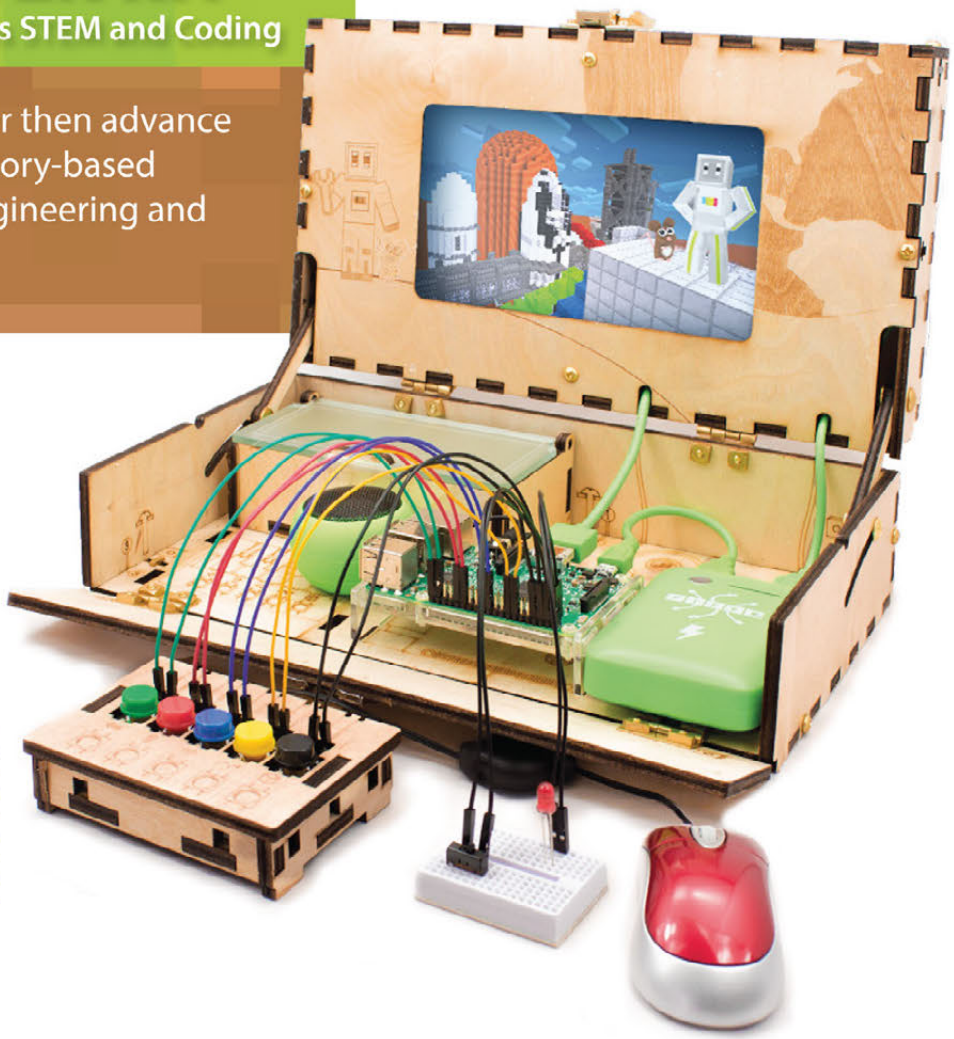

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ARDUINO AND RASPBERRY PI

Combine the ease and accuracy of Arduino with the advanced capabilities of a Raspberry Pi for the best in physical computing projects

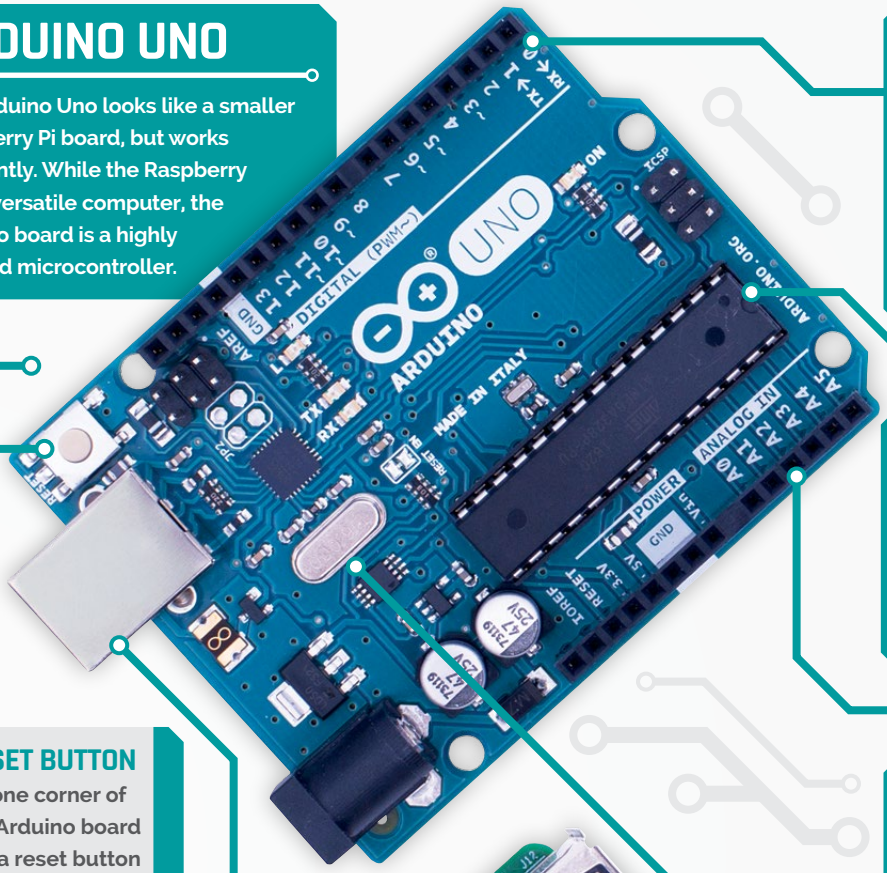
If you want your next project to break beyond the limits of code and screens, you might want to consider adding an Arduino board to your Raspberry Pi. These simple, cheap controllers come in all shapes and sizes and allow you to easily measure, monitor, and manipulate the physical world.

Arduinos are microcontrollers that make physical computing projects quick and easy to build. Whether you're flashing LEDs, activating motors, or sensing changes in the real world, an Arduino is worth considering as part of your project.

This tutorial will take you through the first steps of using an Arduino, and provide examples of fun and useful projects to make. Whether you're building a weather station, constructing a robot, making an alarm for your bedroom, or planning an automatic watering system for the greenhouse, Arduino and Raspberry Pi make a powerful tag team.

ARDUINO UNO

The Arduino Uno looks like a smaller Raspberry Pi board, but works differently. While the Raspberry Pi is a versatile computer, the Arduino board is a highly focused microcontroller.



DIGITAL I/O

The Arduino has 14 digital input/output pins (female header) of which six can be used as PWM (pulse-width modulation) outputs to control devices such as servos, RGB light levels, and other devices that need precision

MICROCONTROLLER CHIP

An ATmega328P microcontroller is used to control the hardware on the Arduino board. It is programmed using the Arduino IDE (accessed via the Raspberry Pi)

RESET BUTTON

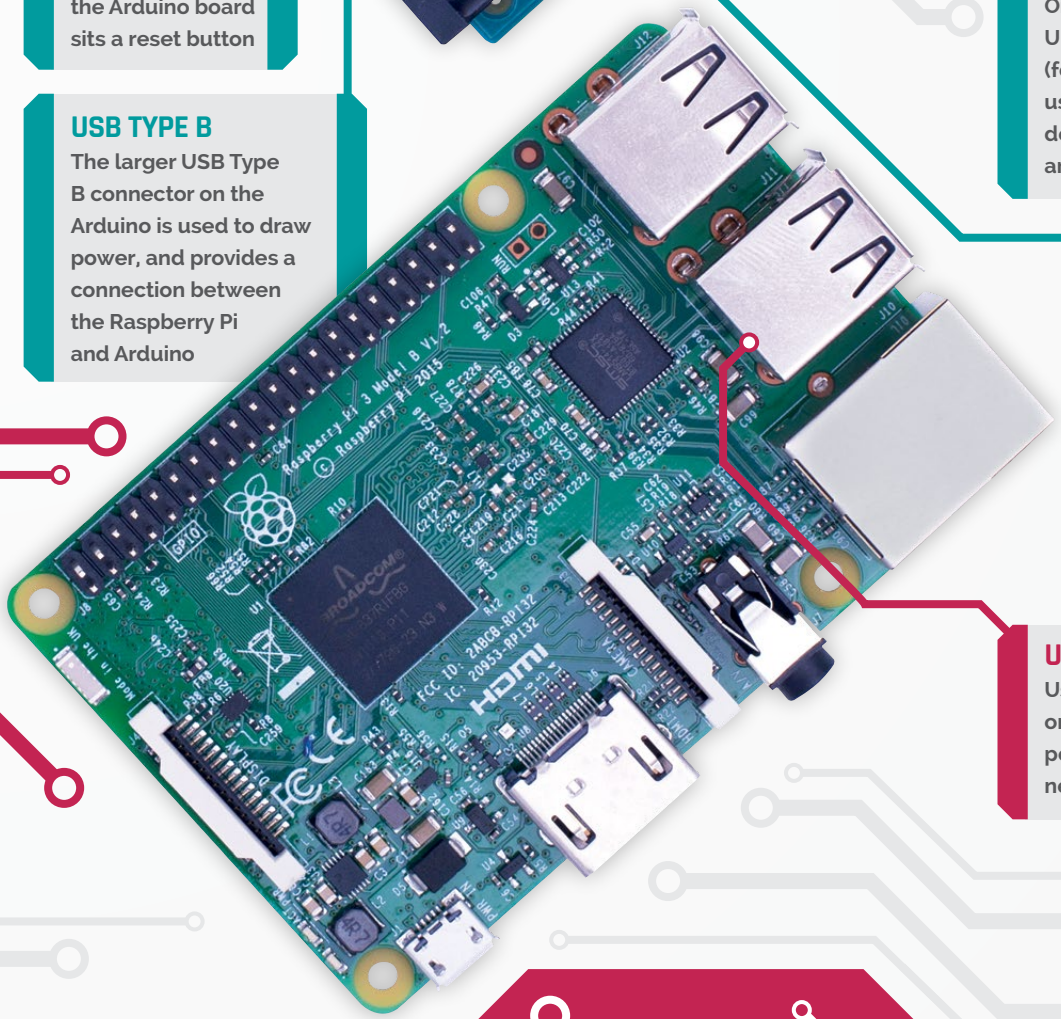
On one corner of the Arduino board sits a reset button

ANALOGUE INPUTS

On the lower half of the Arduino Uno are six analogue input pins (female header). These can be used to read information from devices such as potentiometers and photoresistors

USB TYPE B

The larger USB Type B connector on the Arduino is used to draw power, and provides a connection between the Raspberry Pi and Arduino



QUARTZ CRYSTAL

A 16MHz quartz crystal chip is included on the board. This helps the Arduino control devices with precision

USB TYPE A

Use one of the USB Type A ports on the Raspberry Pi to provide power to the Arduino. You'll need a USB Type A to B cable

CLIVE WEBSTER

A professional tinkerer since 2004, Clive just keeps seeing more uses for Pi around the house – how many Pi boards is too many?
twitter.com/clivewriting

CONNECT THE ARDUINO TO PI

Now you know what an Arduino is, you'll want to discover how to connect it to a Raspberry Pi and use it. We're using an Arduino Uno with a Raspberry Pi 3 for this guide, but the steps are similar for all models.

The first step in programming an Arduino board is to install the Arduino IDE (integrated development environment) on your Raspberry Pi. This program checks code and loads it onto the Arduino. Install the latest version of Arduino IDE using **apt**:

```
sudo apt-get update && sudo apt-get upgrade
sudo apt-get install arduino
```

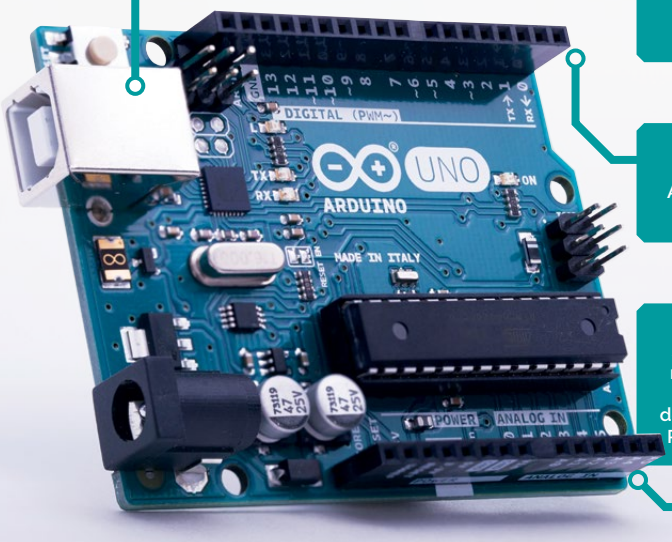
Alternatively, open Chrome on your Raspberry Pi, head to **magpi.cc/2tPw8ht**, and click the Linux ARM link under 'Download the IDE'. Extract the file to your **/opt** directory , then open a Terminal and run the **install.sh** script to install.

```
cd Downloads/
tar -xf arduino-1.8.3-linuxarm.tar.xz
sudo mv arduino-1.8.3 /opt
sudo /opt/arduino-1.8.3/install.sh
```

You will find Arduino IDE under Menu > Programming. Open the app to start programming your Arduino board.

STOP THE PROGRAM

Unlike a Raspberry Pi, the Arduino will keep running the same program, even if you unplug or reset the board. The easiest way to stop it running is to open a new blank program and upload it to the board.



Power the Arduino from one of the Pi's USB ports; this also enables two-way communication

Use the digital GPIO pins of the Arduino to control the electronics

Arduinos have specific inputs to receive analogue information from devices such as our PIR motion sensor

SKETCH YOUR IDEAS

Arduino programs are called 'sketches', and are based on the C programming language. Open the IDE and you'll see a blank sketch, with the two basic areas for code: **`void setup()`** and **`void loop()`**. If you see an empty script, choose File > Examples > 01.Basics > BareMinimum.

As the comments explain, **`void setup()`** is for code that runs once to set up your electronics properly. The code you type into **`void loop()`** will repeat from the first line to the last in an endless loop.

To demonstrate, we've written a basic sketch that flashes two LEDs when you move your hand over a PIR sensor. Connect the two LEDs and PIR sensor to the Arduino, as shown in the circuit diagram (**Figure 1**).

Once you've wired up the Arduino to the circuit, attach it to one of the Pi's USB ports. This provides power to the Arduino, as well as a data connection between your Raspberry Pi and the Arduino board. Do not use the Arduino's barrel-jack power input – a Pi 2 or 3 can supply enough power for an Arduino board over USB.

Enter the code from **PIRBlink.ino** and save it as **PIRBlink** using File > Save. It will be saved inside the Arduino directory in your home directory.

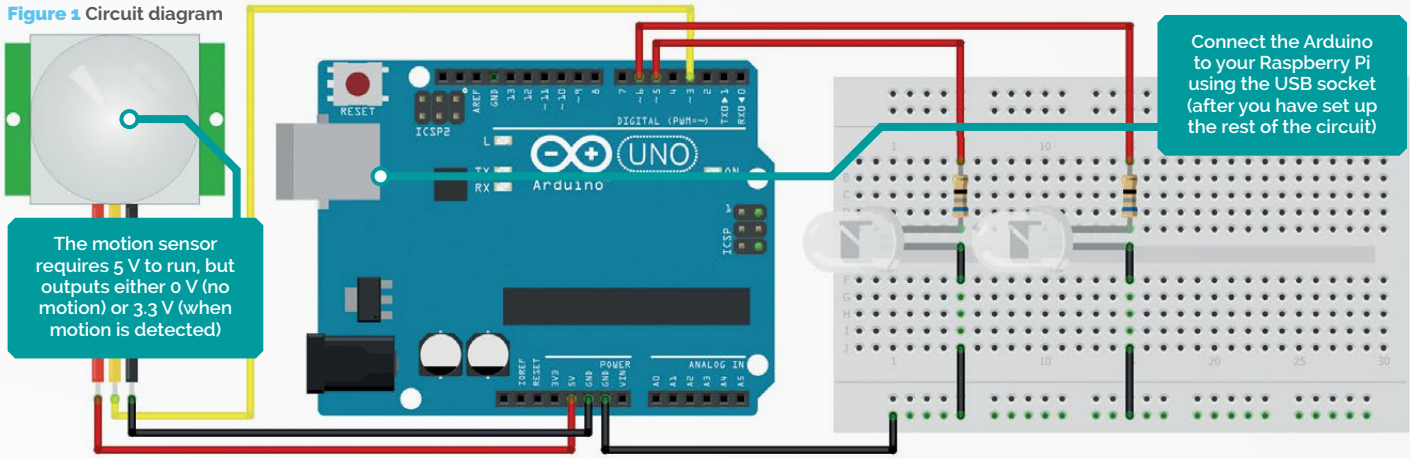
We use the **`pinMode`** instruction to tell the Arduino which GPIO pins the LEDs are attached to (pins 5 and 6) and that each pin should be treated as an output.

In the **`void loop()`** section, we tell the Arduino to raise the voltage on these pins to **HIGH** (5 V) with the

YOU'LL NEED

- **ARDUINO UNO** magpi.cc/2tPLnqE
- **LEDS** magpi.cc/2tPT7sU
- **RESISTORS** magpi.cc/2tPNye1
- **RESISTOR CALCULATOR** magpi.cc/2tPynl9
- **PIR MOTION SENSOR** magpi.cc/2diJivg

Figure 1 Circuit diagram


The motion sensor requires 5 V to run, but outputs either 0 V (no motion) or 3.3 V (when motion is detected)
Connect the Arduino to your Raspberry Pi using the USB socket (after you have set up the rest of the circuit)
UNO
Arduino

digitalWrite instruction, then to pause for half a second, and then to turn off the LEDs.

Before uploading your sketch to the Arduino, tell the IDE which Arduino board you're using by opening Tools > Board. Then tell the IDE which port to use to upload your code by opening Tools > Serial Port and selecting **/dev/ttyACM0**. On version 1.8.3 of the IDE, you need to select the version marked '**(Arduino/Genuino Uno)**'.

Now click Upload to program the Arduino with your sketch. After a few seconds of code-checking and uploading, you should see your LEDs flashing whenever you move your hand over the sensor.

LOOKING AT THE CODE

While not necessary, it's also good Arduino sketch etiquette to include a description at the start.

At the top of your sketch, type **/*** and hit **ENTER**: the IDE will add two more lines. Anything written between the **/*** and ***/** will be ignored by the Arduino, but can be read by any humans wanting to understand what your sketch does and how it works.

We've used variables for our LEDs, meaning that if we change the GPIO pins they're attached to, we'll have fewer edits to make.

We tell the Arduino IDE the type of variable, then the name, and the value. So our LED pins are **int led1=5;**. By replacing all instances of **5** with **led1**, any changes to our build require only one change to our code.

ADD MOTION

We've also added a PIR (passive infrared) motion sensor, as shown in the circuit diagram (**Figure 1**). We therefore declared the variable **int motion = 3** and added this line to **void setup()**:

```
pinMode(motion, INPUT);
```

Finally, we added some code to make the motion sensor trigger the LED flashes:

```
if (digitalRead (motion) == HIGH) {
```

PIRBlink.ino

Arduino | magpi.cc/arduinoandpi

```
/*
 * Blinks two LEDs when motion detected
 */

//variables
int led1 = 5;
int led2 = 6;
int motion = 3;
int wait = 500; //500ms = 1/2s

void setup() {
  // put your setup code here, to run once:
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(motion,INPUT);
}

void loop() {
  // put your main code here, to run repeatedly:
  if (digitalRead(motion) == HIGH){
    digitalWrite(led1,HIGH);
    digitalWrite(led2,HIGH);
    delay(wait);
    digitalWrite(led1,LOW);
    digitalWrite(led2,LOW);
    delay(wait);
    }
}
```

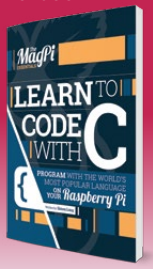
As with the **if** statement, this is part of the **void loop()** section that will run continuously, meaning the motion sensor will be read – or polled – repeatedly for signs of motion.

A final note on coding with Arduino: every line of code must end with either a semicolon or a curly bracket. The IDE will highlight any line of code that suffers an error, and typically it'll be because the previous line lacks its semicolon terminator.

If you are unfamiliar with the C programming language, there are lots of resources you can find online to learn how to use it.

LEARN TO CODE WITH C

Arduino uses the C programming language. To get up to speed with C, read our Essentials Guide: *Learn to Code with C*. magpi.cc/learn-c-book



GET THE RASPBERRY PI AND ARDUINO TO CHAT

SerialLightsRespond.ino

Arduino IDE | magpi.cc/arduinoandpi

```
/*
 * Blinks LEDs when motion detected.
 * LED blink repetition determined
 * by amount in serial_respond_pi_side.py
 */

//variables
int led1 = 5;
int led2 = 6;
int motion = 3;
int wait = 500; //500ms = 1/2s

void setup() {
  // put your setup code here, to run once:
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(motion,INPUT);
  Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:
  if (digitalRead(motion) == HIGH) {
    if (Serial.available()) {
      flash(Serial.read() - '0'); //Converts
                    Serial message into a number
    }
  }
  delay(5000);
}

void flash(int repetitions) {
  for (int i = 0; i < repetitions; i ++){
    digitalWrite(led1,HIGH);
    digitalWrite(led2,HIGH);
    delay(wait);
    digitalWrite(led1,LOW);
    digitalWrite(led2,LOW);
    delay(wait);
  }
}
```

Now that we can program an Arduino with a Pi, let's get the two talking to each other

It is possible to make commands from the Pi (automated or human-activated) affect the sketch loaded onto an Arduino; and for data collected by the Arduino to be sent automatically to the Pi to be processed.

By why would you want to? It's a fair question, as the Pi has plenty of GPIO headers to attach motors, sensors, LEDs, and other devices – why add the complication and expense of a second board?

The answer lies in the simplicity of an Arduino board. It's an easily programmable microcontroller with clearly labelled GPIO pins. An Arduino board therefore has very little overhead to prevent it from taking millisecond-accurate readings, and there's nothing much to go wrong and cause an Arduino to stall or hang.

The Raspberry Pi, meanwhile, has all kinds of hardware and software overheads – from USB controllers and display outputs to wireless connections and a full-blown operating system. All of these can lead to delays or jitters in measurements.

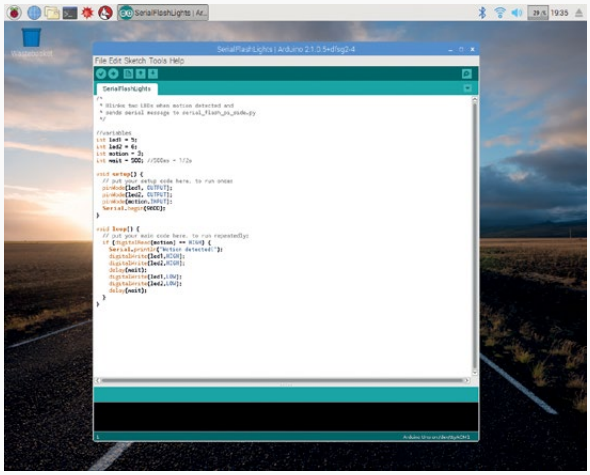
Most Arduino boards have analogue inputs, and can supply a wide range of voltages rather than the 3.3 V or 5 V that a Pi offers. This makes it much easier to connect and code for many electronic components.

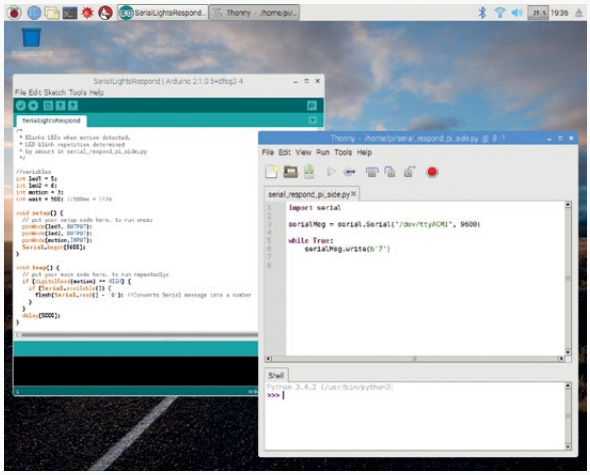
SERIAL COMMUNICATIONS

The standard method of communication between a Pi and an Arduino is serial: it's robust, simple, quick and easy. Let's start with the Arduino, turning our basic sketch into an alarm system.

First, re-save the **PIRBlink** file, renaming it **SerialFlashLights**. Now, we need to enable serial communication, so we head to the end of the **`void setup()`** section and add:

```
Serial.begin(9600);
```





Left The Arduino sketch (on the left) includes a serial read function that gets data from the Python code (on the right)

> Most Arduino boards have analogue inputs, and can supply a wide range of voltages rather than the 3.3 V or 5 V that a Pi offers

The capital S is required (**`serial.begin()`** won't work, so the instruction won't turn orange), while the number sets the speed. Serial connections are measured in baud, with a typical speed of 9600 baud, or 9,600 bits per second.

Next, we need to set up some way of outputting data from the Arduino over this newly opened serial communication. This is fairly easy: just add the line **`Serial.println (message);`** in the **`void loop()`** section. The classic message would be **`hello world`**, but we can skip straight to something more useful with the line:

```
Serial.println ("Motion detected!");
```

We can even test that new code without having to write any code for Pi just yet. Upload the sketch to the Arduino and then click the Serial Monitor button at the top right-hand side. You should see the 'Motion detected!' message whenever you wave your hand at the sensor.

ARDUINO TO PI

Now we can switch to writing a Python script on the Pi. We'll use Thonny, the new Python IDE for Raspbian. If you haven't got Thonny yet, install it with this code:

```
sudo apt-get update && sudo apt-get install thonny
```

Once installed, fire up Thonny. Enter the code from **SerialFlashLights.ino** into Arduino IDE and **serial_flash_lights_pi_side.py** into Thonny. Make sure you

SerialFlashLights.ino

Arduino IDE | magpi.cc/arduinoandpi

```
/*
 * Blinks two LEDs when motion detected and
 * sends serial message to serial_flash_pi_side.py
 */

//variables
int led1 = 5;
int led2 = 6;
int motion = 3;
int wait = 500; //500ms = 1/2s

void setup() {
  // put your setup code here, to run once:
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(motion,INPUT);
  Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:
  if (digitalRead(motion) == HIGH) {
    Serial.println("Motion detected!");
    digitalWrite(led1,HIGH);
    digitalWrite(led2,HIGH);
    delay(wait);
    digitalWrite(led1,LOW);
    digitalWrite(led2,LOW);
    delay(wait);
  }
}
```

upload the code to Arduino first, then run the program in Thonny. Now when you wave your hand, the lights will flash and a message will appear in the Thonny Shell that reads 'Arduino says: Motion detected!'.

> With a bit of practice, you'll be capable of developing some great projects

LOOKING AT SERIAL

First we import the Python serial library with **`import serial`**. We then need to define the serial connection with the Arduino:

```
serialMsg = serial.Serial('/dev/ttyACM0',
9600, timeout = 1)
```

Note that you could use any name rather than **`serialMsg`**. The first argument is the port that the Arduino uses, the second is the baud rate of the serial connection, and it's best to specify a timeout to prevent overloading.

serial_flash_lights_pi_side.py
Python | magpi.cc/arduinoandpi

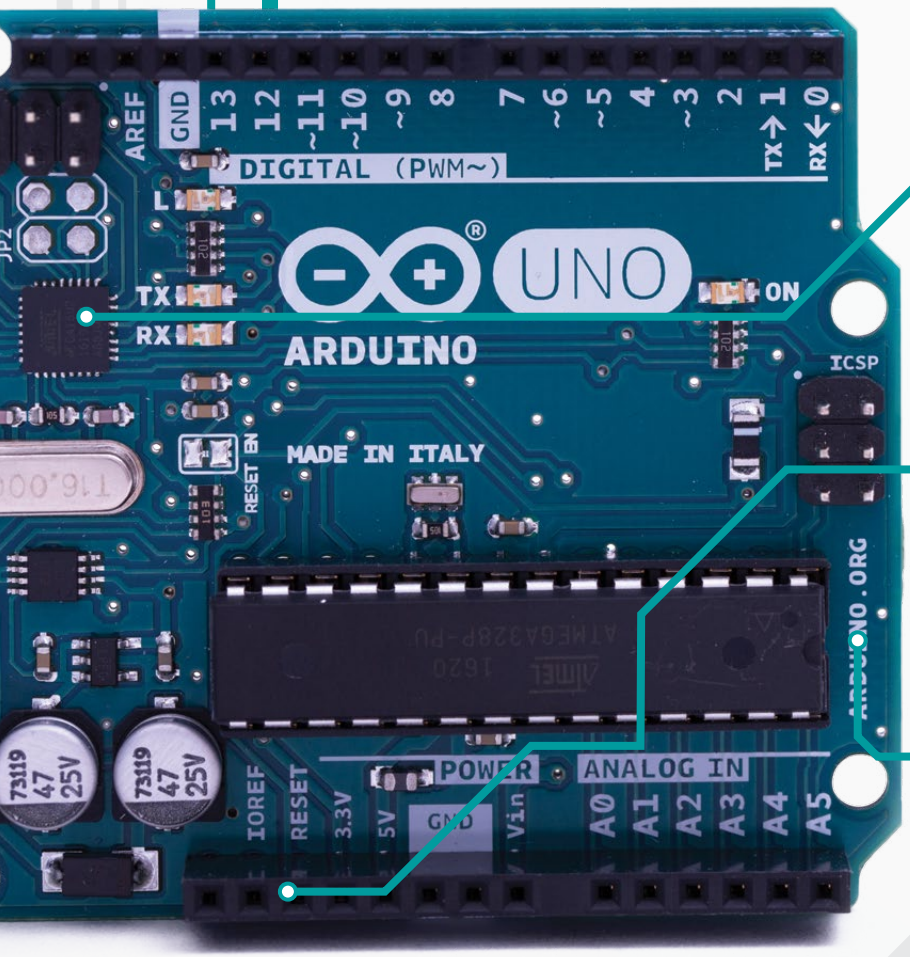
```
import serial

serialMsg = serial.Serial("/dev/ttyACM0",
9600, timeout=1)

while True:
    rawMsg = serialMsg.readline()
    message = (rawMsg.decode().strip())
    if (message == "Motion detected!"):
        print("Arduino says: Motion
        detected!")
```

Next, we read the serial link with the line **`serialMsg.readline()`**. However, the serial connection will change the encoding of the Arduino's message into something unusable. We need to encode the message and strip the extra characters added if we're to use the Arduino's readings to trigger an action in our Python script. That's what the **`message`** variable does in the **SerialFlashLights.ino** code.

You can replace the mundane **`print`** line with almost anything you can think of to make any sensor on the Arduino trigger any kind of event. If your Arduino uses



ATMEGA328P MICROCONTROLLER

The ATmega328P CPU has very little overhead, so it can take millisecond-accurate readings. There's not much that can go wrong and cause an Arduino to stall or hang (and if it does, it automatically reboots and runs the program).

MICROCONTROLLER PINS

Because the Arduino has lower software overheads, it's a useful add-on tool for sending precise readings to the Raspberry Pi.

SERIAL MESSAGING

Serial connections are used to send and read messages to and from each device. The messages are sent via the USB cable that connects the two devices.

serial_respond_pi_side.py
Arduino IDE | magpi.cc/arduinoandpi

```
import serial

serialMsg = serial.Serial("/dev/ttyACM1",
9600, timeout=1)

while True:
```

many sensors, use a different serial message for each so that the Python script can tell which action to take.

PI TO ARDUINO

Having the Arduino react to inputs from the Raspberry Pi is slightly less complicated. In **SerialLightsRespond.ino** we've defined our own function, **`flash()`**. In the **`void loop()`** section, the **`flash`** function's variable **`repetitions`** will be replaced by the number received (and converted) from the Pi, meaning the lights will flash according to the number output by the Pi.

In **serial_respond_pi_side.py** we use **`serialMsg.write(b'7')`** to tell the Arduino to flash the LED lights seven times. The **`b`** is required to properly encode the message for the Arduino to interpret; whether you send text or numerals, they must be placed within quotes.

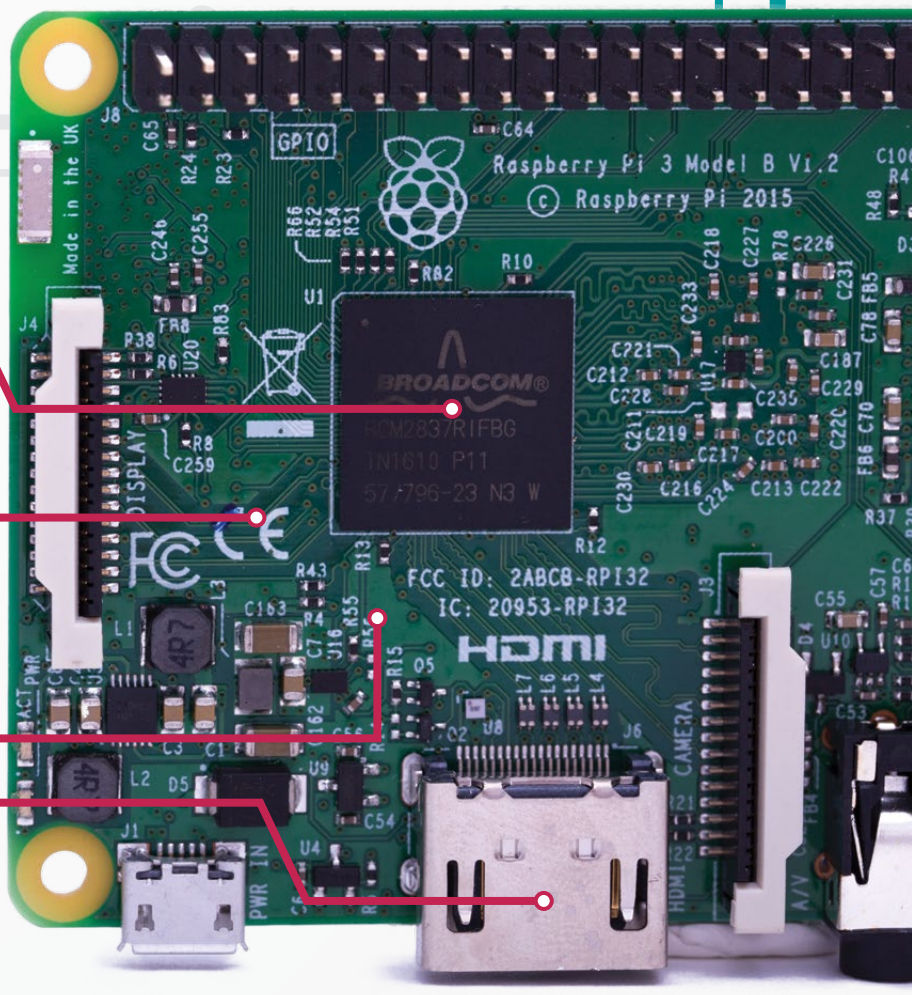
Unfortunately, whether you send letters or numbers, they all arrive as characters – even **`serialMsg.write(b'1')`** will be received as the text character 1 rather than a number.

If you're sending letters to the Arduino, that's not a problem. However, if you do want to send numbers – perhaps to tell the Arduino to flash its LED a certain number of times – you need to convert the numerical character into a numerical number using **`- 0`**, as in our **SerialLightsRespond.ino** code.

When you wave your hand in front of the PIR motion sensor, the LED lights will flash seven times. Adjust the **7** to any number you want in the Python code, and the LED lights will respond accordingly.

READY TO GO

You've linked an Arduino to a Raspberry Pi and discovered how to control its input/output pins, how to read information from the Arduino, and how to send messages from the Raspberry Pi to the Arduino. With a bit of practice, you'll be capable of developing some great projects.



BCM2837 SYSTEM ON CHIP

The Raspberry Pi packs far more processing power than the Arduino Uno. This enables the Raspberry Pi to run a full Linux desktop interface, and manage the higher-level functions.

SERIAL CONNECTION

The Raspberry Pi can communicate with the Arduino using serial communication. Open a port between the Arduino and the Pi in code (libraries are available for Python and C).

HDMI OR DSI

The Raspberry Pi's HDMI and DSI video output ports enable it to run a visual interface. They can therefore be used to turn the Pi into a controller for the Arduino.

PROJECT IDEAS

GALAGA ARCADE CABINET

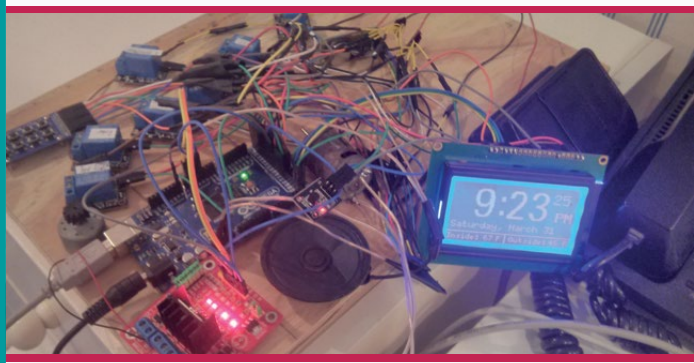
Galaga. That 1981 arcade game of champions. While you can play Galaga in your browser (**freegalaga.com**), nothing beats the look of a light-up arcade cabinet, complete with sticks and giant buttons. In fact, Hamburg's Alex Weber went even further, rescuing an old CRT television from a skip to connect to a Pi running MAME through RetroPie (**retropie.org.uk**).

magpi.cc/2vbNDZe

INTERNET OF LEGO

An entire city, built from Lego and controlled by Arduinos, Raspberry Pis, and bundles of sensors. All the parts interact with each other, with myriad sensors placed around the blocky cityscape to track events within the city and in the real world. The whole connected city is powered by a Raspberry Pi running the Node-RED Internet of Things manager (**nodered.org**).

internetoflego.com



HAMMOND SMART HOME

For his 'HAMMOND' smart home system, Paul Sieradzki used an Arduino Mega to manage everything from motors that roll blinds, temperature sensors and PIR motion sensors, to relays to control power, IR blasters, and RFID readers. There's a Pi on top to gather weather information, add web access, and manage Alexa-based voice recognition. A second Pi serves video and music.

magpi.cc/2vb6NPe

PIANO STAIRS

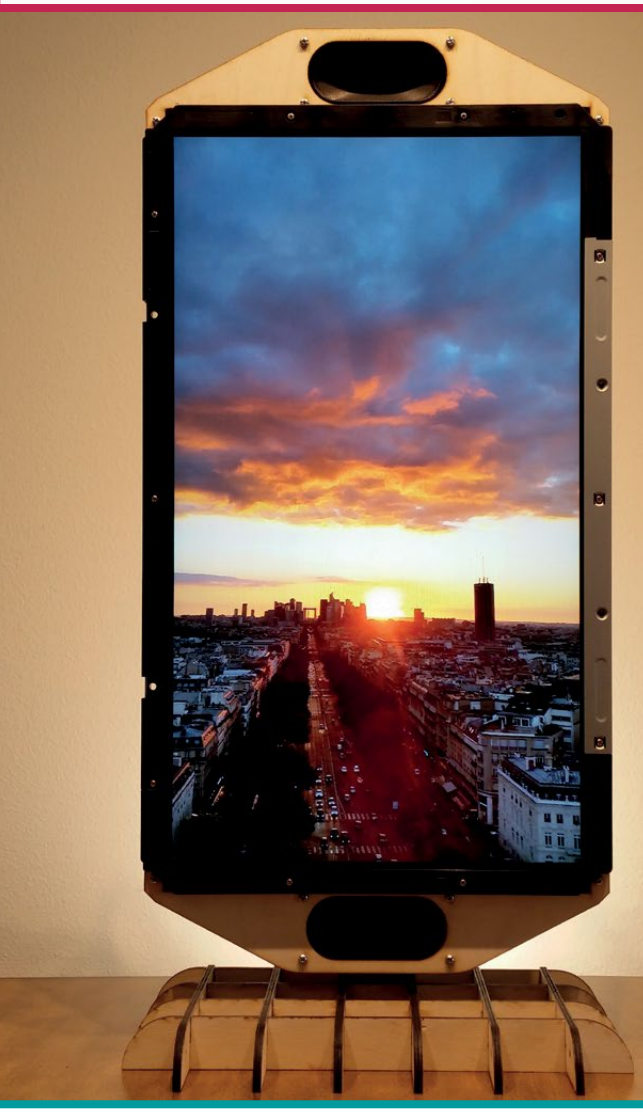
As part of a HackPrinceton hackathon, Bonnie Eisenman created stairs that play a tune. Each step is fitted with a light on one side and a light sensor on the other; when a foot breaks the beam, an Arduino passes the number of the step to a Raspberry Pi, triggering a specific note to be played through a set of speakers.

magpi.cc/2vbAE9T

SMART JUKEBOX

Tijuana Rick (aka Ricardo Cortez) used an Arduino Mega to transform a 1969 Wurlitzer 3100 jukebox into a digital retro music box. He had to go the digital route because, while the jukebox still worked, the previous owner kept all the vinyl records. The Arduino monitors the jukebox buttons, sending a serial output to the Pi, which handles the music playback.

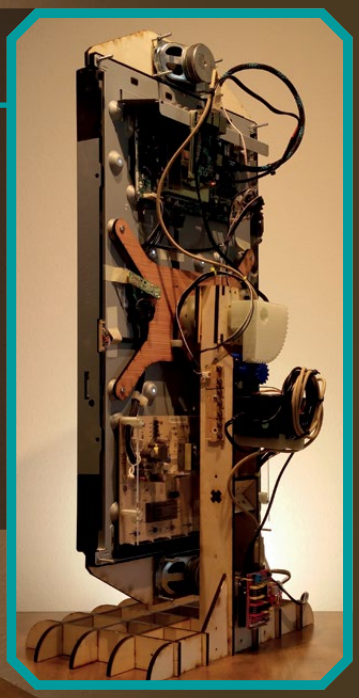
magpi.cc/2vbTbDI

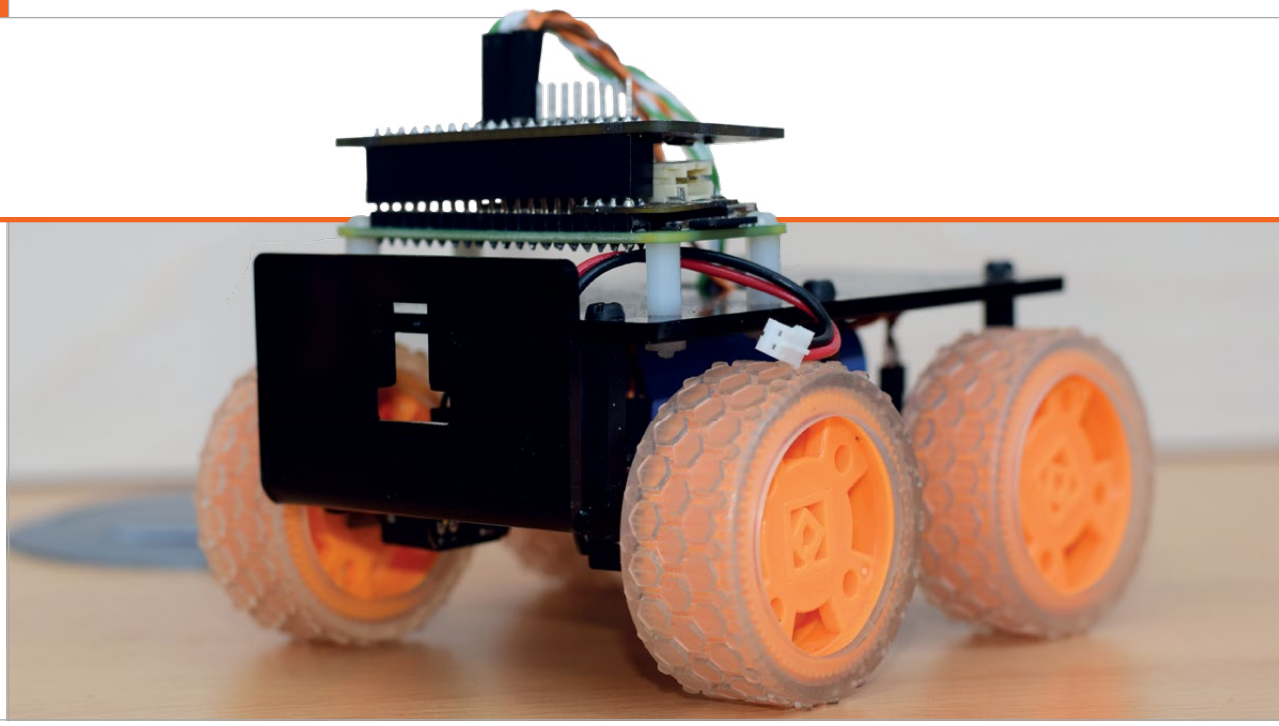


FLIPFRAME

FlipFrame solves the problem of showing a slideshow of mixed-orientation images. Obviously, black bars are insufferable, so Tim Giles uses a Raspberry Pi to analyse his slideshows. If the resolution indicates a landscape image, the Pi tells a motor-governing Arduino to turn the FlipFrame's 27-inch screen from landscape to portrait mode. It is a sight to behold.

magpi.cc/2vbQ032





Maker Says

"Tiny 4WD is a small but powerful robot that you build yourself"

Coretec

TINY 4WD ROBOT KIT

Rob Zwetsloot looks at a tiny robot with a lot of power, in a kit based on a robot you might remember from the magazine

If you cast your mind back to issue 51 of the magazine, you'll remember a robot on the cover that you could make yourself. Its designer, Brian Corteil, has taken the lessons from making that robot to build an all-new improved version, which you can buy directly from his Coretec website (**magpi.cc/Tiny4WD**) and from **pimoroni.com**.

The Tiny 4WD is the end result of this learning process, and is available as a kit that you build yourself. All you need to supply is a Raspberry Pi and a way to power it (a mobile USB battery charger will do the trick). The kit is optimised for a Pi Zero, with specific mounting points on the chassis. However, we tested it using a Raspberry Pi 3 and it worked well.

Easy build

The build is fairly quick. There are only three parts to the chassis, and one of these isn't necessary in its basic state. The box recommends using the build in *The MagPi* as your instructions, but they don't quite fit this kit. Luckily, there's a great guide online, linked from the Pimoroni website: **magpi.cc/2pXHCu8**. Online instructions aren't ideal – it would be nice to have printed instructions in the box – but it's enough to get you started.

We managed to get the robot up and running in just under two episodes of *Brooklyn Nine-Nine*, so we'd estimate 30–40 minutes' build time, but it may take longer depending on your skills with a soldering iron. You'll need to

> "The kit is optimised for a Pi Zero, with specific mounting points on the chassis"

Related

GOPIGO 3

A more expensive kit, but it does come with sensors for some proper robotics. It's even easier for newbies as well.

£95 / $99

magpi.cc/2vpUPP8

magpi.cc/Tiny4WD

£55 / $72

solder a 40-pin and a 20-pin header to the Explorer pHAT supplied with the kit, as well as soldering a GPIO header to the Pi Zero. The rest of the setup is easy: install the software on the Pi Zero (running Raspbian) and you're ready to play!

Flexible control

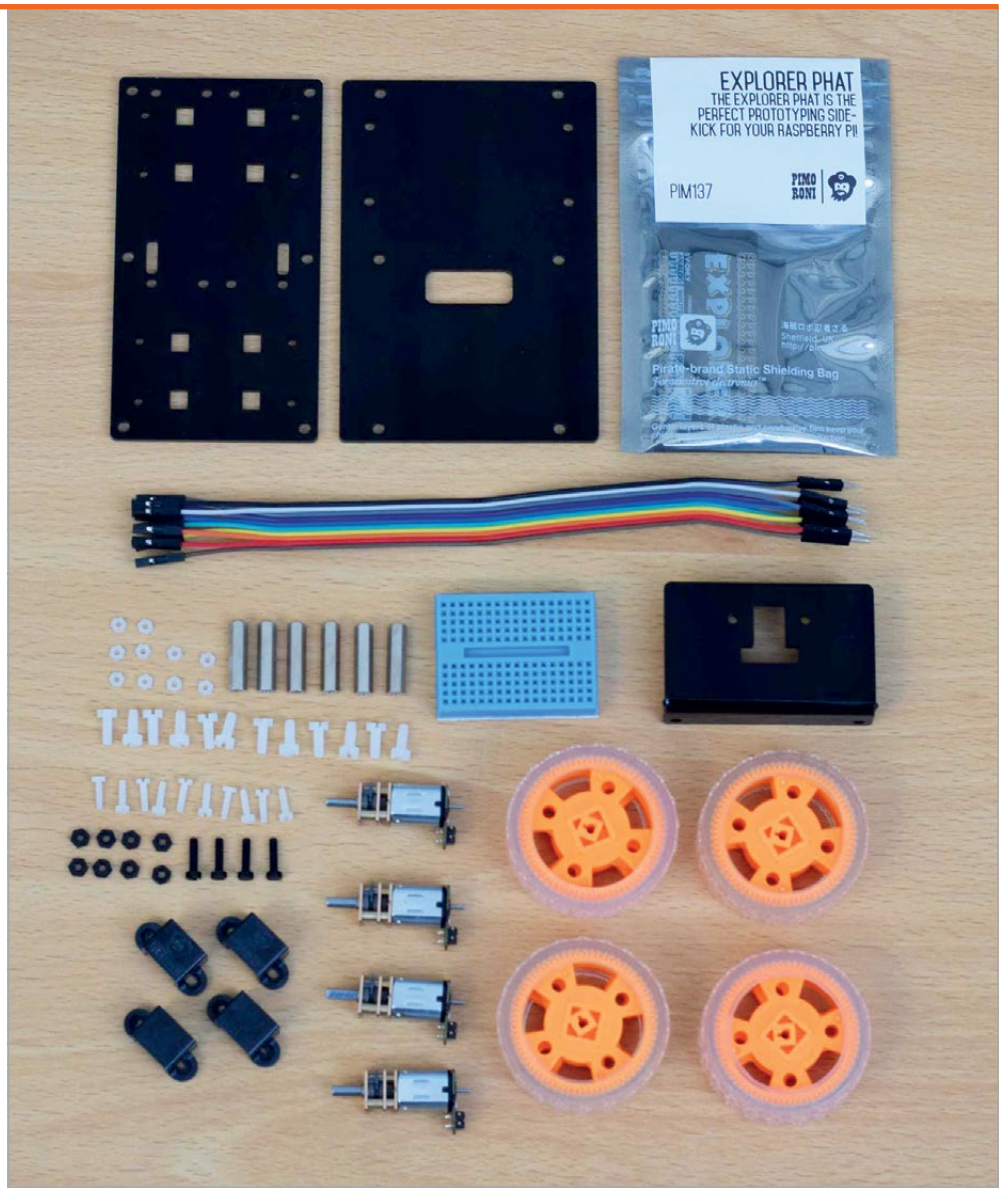
From here you can use the test scripts to control the robot using a USB controller, or start making it more autonomous. The Pimoroni library for the Explorer pHAT is easy to understand – so, with the docs open and the examples to hand, you can easily start creating your own programs.

Each side of the Tiny 4WD is powered by one of the motor outputs on the pHAT. This means that, for example, both left wheels will always run at the same speed and direction as each other. This makes it easy to turn on the spot, and gives it full power when it's moving forwards and backwards.

The Tiny 4WD is easy to customise. There are extra inputs and outputs on the board, so you can start adding additional sensors. There's a camera mount that could be used to attach an ultrasonic sensor, or a Raspberry Pi Camera Module – like the robots in the Formula Pi racing series.

Power choices

Choosing a power supply can be tricky. The idea is to house your power source between the layers of the chassis. However, the narrow gap, partly blocked by the wires to the motors, limits the size of any power supply. You'll also need to think about power capacity – the motors will be powered from the Pi's GPIO pins, so your Pi will need more power than you might expect.


EXPLORER PHAT
THE EXPLORER PHAT IS THE PERFECT PROTOTYPING SIDE-KICK FOR YOUR RASPBERRY PI
PIM137
PIMORONI
Pirate-brand Static Shielding Bag

Thumbs up

We do like this robot overall. The build quality is great, with a sturdy chassis made from thick acrylic, decent micro motors supplied with the kit, and the inclusion of a great motor controller in the Explorer pHAT. The soldering requirements make it unsuitable for an absolute beginner, but it'd be great as a step up for novices. It could even be used as a base by more advanced robotics users, as you can easily swap out the HAT and use a bigger Pi to add more functionality.

Unfortunately, supplies are limited for this kit, but more units are being made all the time. If you want one, you may just have to be patient. We think it's worth the wait, though.

Last word

A great little robot kit which could do with some better build instructions. Once it's built, however, you have a lot of options and plenty of ways to make it your own.

★★★★☆

rasp.io/inspiring

From £10/$13

Maker Says

"Connect RGB LED shapes. Sculpt your lights"

RasPiO

RASPIO INSPIRING

Create impressive illuminations with this dazzling range of light kits

The main selling point of RasPiO InsPiRing is the ability to daisy-chain a variety of LED strips and shapes together to create 2D and even 3D displays. Now headed for general sale following a successful Kickstarter, the range comprises four kits: a strip of eight LEDs (£10/£13), a circle or triangle of 24 LEDs (£20), an NTP Clock kit including Pi Zero (£30), and a pyramid kit featuring three 24-LED triangles (£50).

Although the super-bright APA102c LEDs can be controlled by other devices – including Arduino, ATtiny, and ESP8266 – each kit comes with a pHAT-sized driver board for the Pi, communicating via SPI. Assembly takes around 20 minutes and involves soldering on a 40-pin header, two small female headers, and a socket for a buffer chip. The chip translates the Pi's voltage to 5 V logic to drive the LEDs. The power supplied by the Pi alone should be enough for most projects, but there's the option of boosting it with an external 5 V power supply if needed. Jumper wires are supplied for connecting the light strips and shapes to the Pi, along with a couple of optional 10 kΩ resistors (not needed in most cases). There's also the option of a header for analogue inputs, so you could control your lights with potentiometers, for instance.

Male and female four-pin connectors are supplied for each LED strip and shape, enabling you to daisy-chain units together. Three sets of input/output holes are provided at each end, so you can solder your connectors at various angles: 180°, 90°, or 45°. This offers more flexibility when connecting units to create custom light displays, although you can always just wire directly to the holes if you prefer.

Indeed, that's what you'll be doing for the pyramid kit. After assembling the 3D shape from three triangles, held together using pieces of sticky tape, you'll need to solder bare wires between the input/output holes at each vertex, which is fairly fiddly.

Once the hardware is assembled, the software is installed on the Pi with a single command and includes a range of Python examples which can easily be adapted for your own purposes.

Related

MOTE

Instead of daisy-chaining, each super-bright LED strip (no shapes) is connected separately to a pHAT or USB-connected host.

From £16/$21

magpi.cc/2g9iyLs

Last word

This range of LED lighting kits offers flexible daisy-chain connectivity that enables makers to 'sculpt' custom arrangements of shapes. The end results are impressive: the super-bright LEDs creating some dazzling displays. The pyramid is a particularly fun (if fiddly) project to make, and would make a great gift.

★★★★☆

READ US **ANYWHERE**

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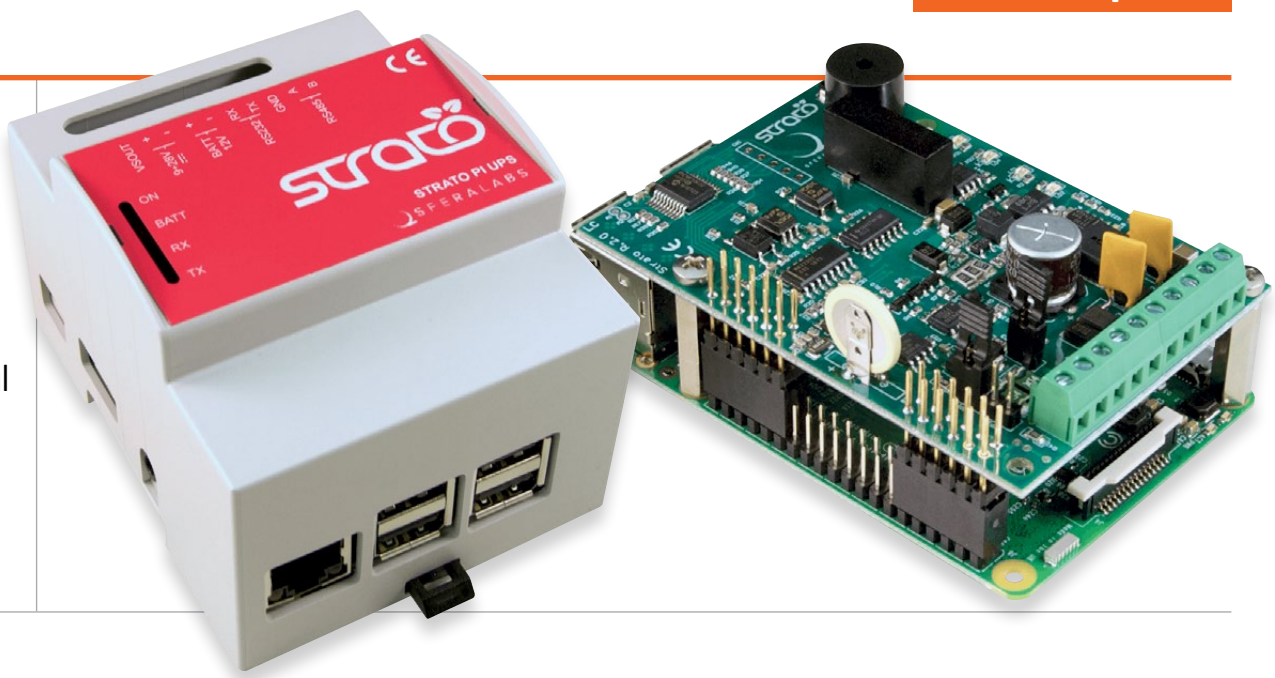
sferalabs.cc/strato-pi

£106 / $138

Maker Says

"Makes Raspberry Pi more professional"

SferaLabs



STRATO PI CAN

Lucy Hattersley looks at an industrial solution for Raspberry Pi

The Raspberry Pi has slowly been making its way from the digital hobbyist's garage into professional manufacturing environments. SferaLabs specialises in smart control systems, and its Strato Pi boards are a great attempt to add commercial-grade hardware to the Raspberry Pi board. There's a range of different boards available, and we're looking at the top-of-the range CAN board, which has all the bells and whistles.

Most of the Strato Pi boards accept 9–28 V, while this board uses 9–65 V DC power. A high-quality power supply ensures reliable operation of a Raspberry Pi when it's being used 24/7. The board has a step-down converter to provide the 3 A continuous output. It also features power surge protection (up to ±500 V, 2 ohms, 1.2/50 µs).

The CAN board also features UPS (uninterruptible power supply). In the event of power loss, it offers enough time to save data and perform a clean shutdown.

Another nifty feature is Hardware Watchdog, which monitors the software running on the Pi. The Strato Pi Can monitors a GPIO 5 heartbeat pin (which takes less than 60 seconds to change state). If it doesn't see a change, it initiates a shutdown procedure and raises GPIO 12 to HIGH, which can signal to your code that a watchdog timeout has occurred, allowing you to run a script.

On the end of the Pi CAN board is an 11-position terminal block. Power runs into this block, and it provides a CAN (Controller Area Network) bus and RS-485 ports, both of which can be used at the same time. The CAN controller is used in automotive environments, and you can use it to interface with a car's internal network.

Eight of the GPIO pins are used to control the real-time clock, CAN controller, buzzer, and for power management; but you can still use the remaining pins for pass-through control. You can view circuit diagrams and find usage instructions in the user guide (**magpi.cc/2ut7y33**) and schematics (**magpi.cc/2ut6z34**).

A Strato Pi utility is used to control the buzzer, watchdog, and UPS, installed using:

```
sudo wget http://sferalabs.
cc/files/strato/strato
```

Related

PICAN 2

This PiCAN2 board provides CAN bus capability for the Raspberry Pi. It uses the Microchip MCP2515 CAN controller with a MCP2551 CAN transceiver.

£33 / $47

magpi.cc/2ut8ftb

Last word

Strato Pi CAN is a high-quality board, with specific features for use in a production environment.

★★★★☆

magpi.cc/2w1RKow

£22 /$29

Maker Says

"A low-energy, high-falutin, red/black/white electronic paper display for your Pi!"

Pimoroni

INKY PHAT

Add a little more colour to your e-Ink display, says **Phil King**

With the ability to display text and images that remain on screen without using a power supply, e-Ink displays are ideal for saving precious battery life in portable projects. They're also much easier to view in bright sunlight than conventional screens.

Until now, Pi e-Ink displays have been black and white – but the tri-colour Inky pHAT injects a bright shade of red into the mix. This certainly adds a dash of extra interest to images, such as the logo shown on the display when you unpack your pHAT.

Unlike the rival PaPiRus Zero, the Inky pHAT comes fully assembled, with the e-Ink screen already mounted and connected to the board via a small ribbon cable. This saves fiddling about with a thin and fragile screen, although you still have to take care not to press on it when mounting the pHAT on the Pi's GPIO pins.

While the Inky pHAT has a Zero form factor, it'll happily work with any 40-pin Pi model. Communicating via SPI, it only uses six GPIO pins (plus 3 V and 5 V power). If you wanted to locate the screen away from the Pi, however, you'd need to use something like a Black Hat Hack3r (**magpi.cc/2fqGyoD**).

A single Terminal command installs all the software required. The Python library comes with a few helpful examples, including a calendar and a weather display. There's a lot of flashing and pulsing as the screen refreshes, the red parts usually appearing last. While the end result looks vibrant, the downside is a much slower refresh time compared with a monochrome e-Ink screen – typically around 15 seconds vs 1 second or less. The badge example takes even longer, but demonstrates the ability for a partial update, adding text (your name) to a background image.

The slow refresh rate makes the Inky pHAT unsuitable for scrolling text, but static text can easily be displayed in any installed TrueType font, using a simple **message** function in Python. Images are a bit trickier, as you need to prepare them in a special indexed colour mode, and they must also exactly match the size of the display at 212 × 104 pixels.

Last word

While the slow refresh rate makes the Inky pHAT unsuitable for some projects, it does look far cooler than a standard monochrome eInk display. If you want a low-power, battery-saving screen with a little more pizzazz, this is the one to get.

★★★★☆

Related

PAPIRUS ZERO

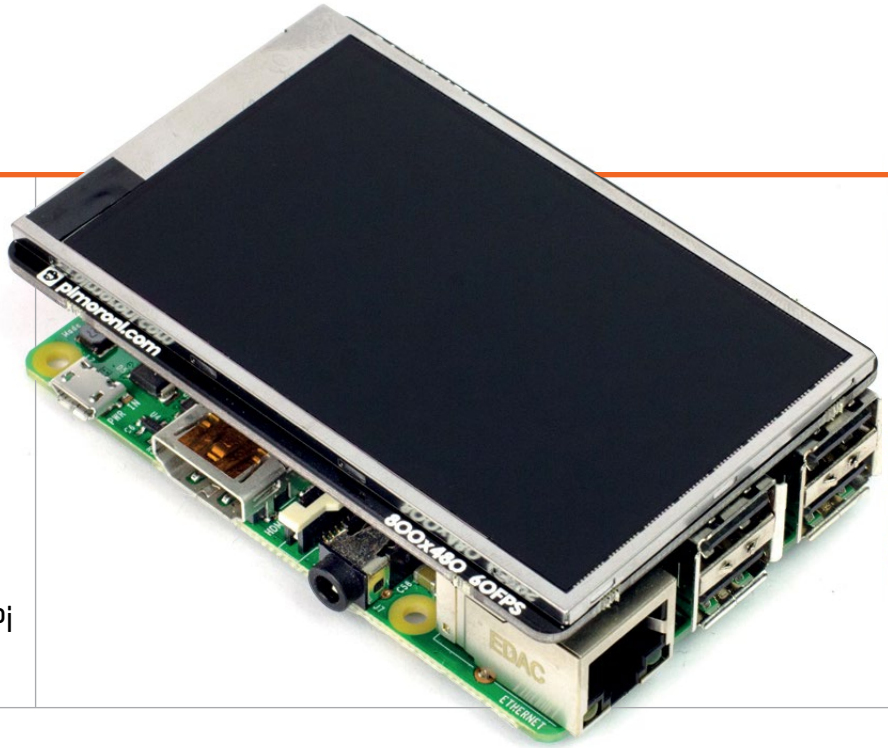
Available in a range of sizes, this black-and-white eInk display has a far faster refresh rate, plus push-buttons to control what's shown on screen.

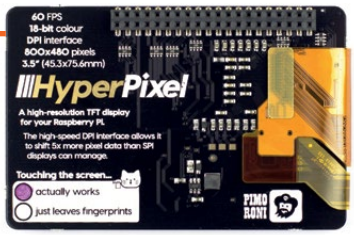
From £27 / $35

magpi.cc/2ou5KTh

magpi.cc/2ueAs8L

£40 /$52





Maker Says

"A high-resolution, high-speed 3.5-inch TFT display for your Raspberry Pi

Pimoroni

HYPERPIXEL

Vibrant mini screen packs a lot of pixels into a small space – **Phil King**

While most small screens connect to the Pi's HDMI socket, the HyperPixel is a HAT that plugs onto the GPIO pins. It comes pre-assembled, so no soldering is required. On a Pi Zero, it mounts straight on top for a flush fit. For other Pi models, an extra female header is supplied to raise the HyperPixel so it sits on top of the Pi's USB ports. A rubber foot (to stick to the top of the Ethernet port) and a support bolt are also supplied to provide extra stability.

Before you can use the HyperPixel, you'll need to install some software. Fortunately, as with most Pimoroni products, you can use a one-line installer command in the Terminal. To enter the command you'll need to hook the Pi up to another monitor, or access it remotely via SSH. When the software has been installed, the Pi will only display to the HyperPixel, unless you revert the config.txt file.

Once it's all up and running, you're sure to be impressed by the HyperPixel's performance. The 800×480 resolution matches the official Pi 7-inch touchscreen, and with a pixel density of 270 ppi, the HyperPixel beats its rival 3.5-inch screens. The display looks seriously sharp with vibrant colours (18-bit for 262,144 shades) and good viewing angles. There is some occasional colour banding when displaying fine gradients, but it's hardly noticeable. With a frame rate of 60 fps, videos look superb – although we noticed a tiny bit of distortion at the right-hand edge when streaming YouTube videos (but not when playing those stored locally).

That frame rate is down to the use of DPI (Display Parallel Interface). The downside to this is that the 18-bit colour uses 18 GPIO pins, while the rest are needed for functions including syncing and two-point capacitive touch. I²C and SPI are also disabled. Naturally, this limits the screen's usefulness for some projects. In addition, if you want to use PWM for fine control of the backlight brightness, you won't be able to output audio via the Pi's 3.5 mm jack.

Last word

While not suitable for projects requiring GPIO pins, the HyperPixel is ideal for use in a mini media centre, portable retro games console, camcorder (see magpi.cc/2tjrgNq), or as a touchscreen interface. Since the Raspbian desktop is too fiddly to control in miniature, you'll want to create your own custom GUI. Whatever you use it for, this is a stunning screen.

★★★★☆

Related

ADAFRUIT PITFT PLUS 3.5-INCH

This 480×320 screen also plugs into the GPIO pins, but only uses eight of them. It has a resistive, rather than capacitive, touch interface.

£45 / $45

magpi.cc/2uf3kxq

magpi.cc/2vXvQDb

£40/$50

Maker Says

"pi-top PULSE brings the arts into STEAM"

pi-top

PI-TOPPULSE

A new multimedia add-on that brings lights and sound to a pi-top or a Raspberry Pi. **Rob Zwetsloot** takes a look

We love the pi-top range of computers. They provide true PC or laptop conversion kits for the Raspberry Pi, customisable with plug-in modules and aimed at educational users. Usually these add-ons are designed to enhance the experience of using the pi-top, but that's all changing with their latest and most ambitious add-on, the pi-topPULSE.

It may be ambitious, but it is also very cool. From the top, it's an unassuming white plastic square. It includes a 7×7 LED display under the plastic, plus a microphone and speaker. The PCB is visible on the underside, but it is lovely and well designed.

On its own, it can be plugged into a pi-top using the special magnetic rails inside the slide-out compartment, but it can also be used as a HAT on the Raspberry Pi. You'll need to plug in a header to the underside of the PULSE before popping it on the Pi, but it works with Raspbian after installing a single piece of software.

It's a very tight fit on the Pi. The case barely misses the Ethernet port, and the connectors for the pi-top hang over the board, increasing the footprint of the Pi. As an educational tool it is excellent, with a very robust Python library for creating light displays and games.

The microphone and speaker give you access to other functions. The PULSE acts as a fully integrated speaker for Sonic Pi, and is even optimised for use with Amazon Alexa on the Raspberry Pi. There's a great demo on the product page that shows how it can be used with Alexa.

It is a little tricky to get your head around the programming, but there are plenty of examples that helped us figure out how to use everything.

All in all, it's one of the most fun HATs we've seen in a while, allowing users to explore many amazing project ideas.

Related

UNICORN HAT HD

With its programmable 16×16 RGB LED display, this is a great HAT that is easy to code and fun to use in a range of projects.

£32 / $41

magpi.cc/UniHATHD

Last word

An amazing idea with great execution – we just wish it was slightly easier to program. With a bit of practice you can create some astounding things with the PULSE.

★★★★☆

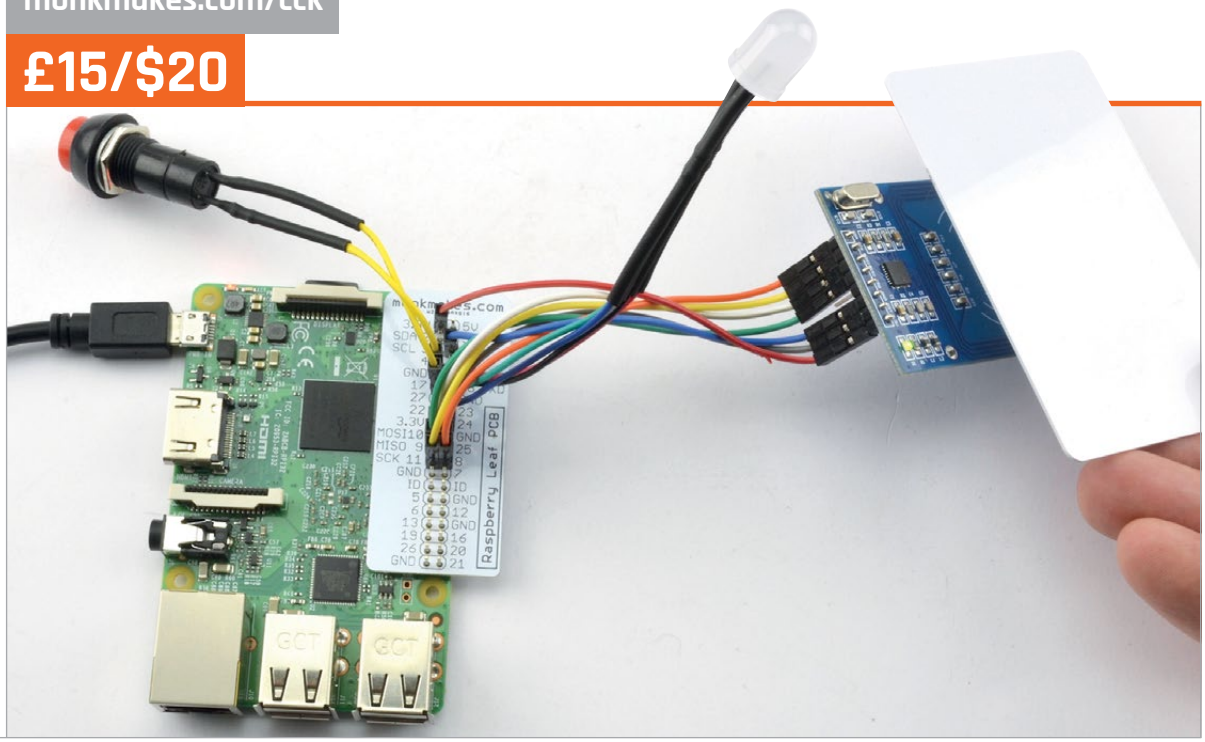
Maker Says

"Providing you with hours of entertainment building projects that can read and write from 13.5 MHz contactless RFID smart cards"

Monk Makes

monkmakes.com/cck

£15/$20



CLEVER CARD KIT

Rob Zwetsloot adds RFID tags to his projects with a set of rewritable contactless cards and this special add-on

Related

RAINBOW HAT STARTER KIT

This kit doesn't use RFID, but it does allow you to interact with the environment, time, and the internet to learn about code and then make your own amazing things

£80/$103

magpi.cc/2vXINwQ

In this issue of *The MagPi* we have a tutorial on creating an automation system with Bluetooth tags, using the Pi Zero W's built-in Bluetooth connection to detect Bluetooth signals (page 22). This project is based on the concept of key cards and other contactless RFID technology. Now, thanks to this kit, you can easily create your own Pi-based RFID projects.

> "This project is based on the concept of key cards and other contactless RFID technology"

This simple, cheap kit allows you to add an RFID reader to a Raspberry Pi. It comes with six RFID-compatible cards and an RFID key fob. Being a Monk Makes kit, it also comes with some other goodies to help you play with your new project, including a push button and an RGB LED. The lovely printed booklet that comes with the kit includes instructions for projects that use the extra goodies, and takes you through the easy Python code needed to set up the reader.

The book starts with some basic projects and finishes off with a special 'Monopoly' project, which allows you to assign money to each RFID card and play the game without using stacks of cash.

It's a wonderful little kit, and it's so easy to use. The projects in the book require absolutely zero soldering – although if you want to make something a little more complex, you can always get your soldering iron out. It doesn't require much extra software installation either, so we had the reader up and running in no time. Finally, the inclusion of the cards and key fob are very welcome – we already have some ideas for projects using these in the future.

And did we mention that it's only £15? That's a bargain any day of the week.

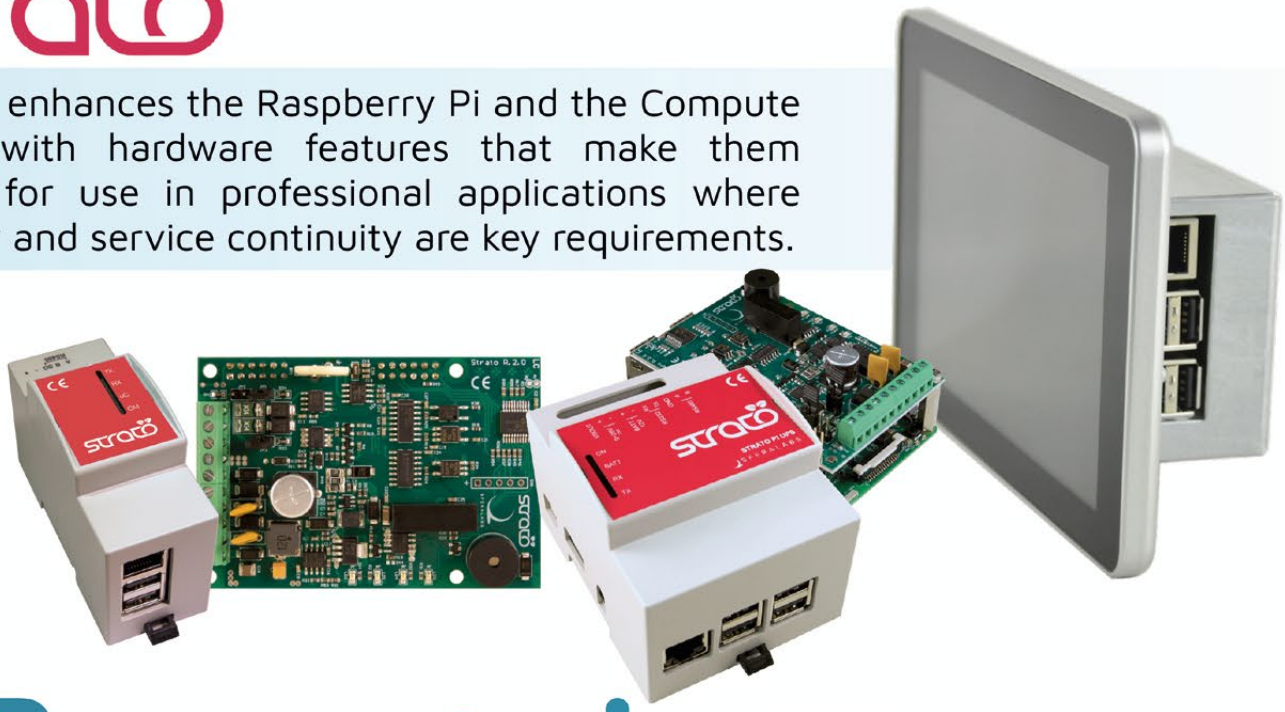
Last word

A really fun kit idea from Monk Makes that does a great job of teaching you how to use RFID readers, and inspires you to go out and do much more with the technology.

★★★★★

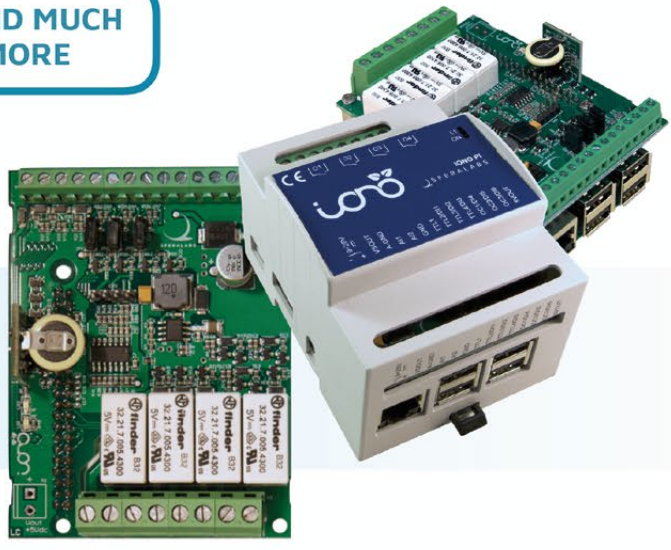
Raspberry Pi for professional applications

Strato Pi enhances the Raspberry Pi and the Compute Module with hardware features that make them suitable for use in professional applications where reliability and service continuity are key requirements.



- CE/ROHS CERTIFIED
- REAL TIME CLOCK
- HARDWARE WATCHDOG
- DIN-RAIL CASE
- CAN BUS
- UPS
- POWER RELAY
- RS-232 / RS-485
- WIDE RANGE POWER SUPPLY
- MODBUS
- .. AND MUCH MORE

Iono Pi is a versatile I/O module that combines digital and analog standard interfaces with the powerful computing core of the Raspberry Pi.



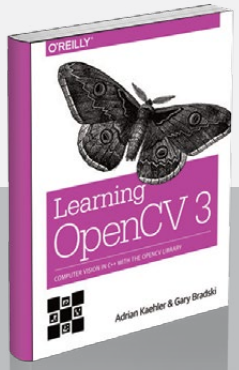
SFERALABS | www.sferalabs.cc

RASPBERRY PI BESTSELLERS COMPUTER VISION

A camera is just a piece of hardware. Vision lies in software – and understanding.

LEARNING OPENCV 3

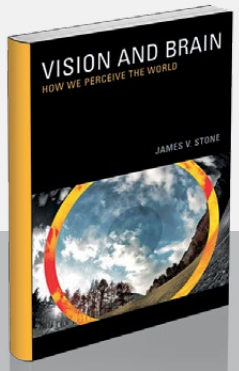
Authors: Gary Bradski & Adrian Kaehler
Publisher: O'Reilly
Price: £59.99
ISBN: 978-1491937990
magpi.cc/2hGVLM4



Targeting the C++ API, Kaehler and Bradski's near 1,000-page work covers every aspect of real-time image processing library OpenCV, as well as some useful insights into computer vision in theory and practice.

VISION AND BRAIN: HOW WE PERCEIVE THE WORLD

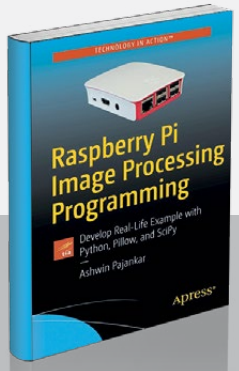
Author: Dr James V Stone
Publisher: MIT Press
Price: £29.95
ISBN: 978-0262517737
magpi.cc/2ulRAqA



A computational theory of vision. Dr Stone's enjoyable and accessible look at the how and why of animal and human vision will give you a fresh perspective on the subject.

RASPBERRY PI IMAGE PROCESSING PROGRAMMING

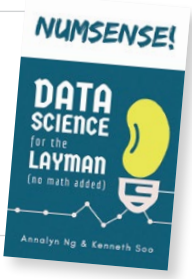
Author: Ashwin Pajankar
Publisher: Apress
Price: £14.99
ISBN: 978-1484227305
magpi.cc/2umpuj9


Raspberry Pi Image Processing Programming
Develop Real-Life Example with Python, Pillow, and SciPy
Ashwin Pajankar
Apress

Putting it all together on the Pi: a compact but useful introduction to Python-based image capture and processing on the Pi, with pillow, scipy, and matplotlib.

NUMSENSE!

Authors: Annalyn Ng & Kenneth Soo
Publisher: Annalyn Ng & Kenneth Soo
Price: £23.99
ISBN: 978-9811110689
magpi.cc/2umfEOg



Data science is everywhere (as is hype about data science), as intelligent analysis of petabytes of new data becomes essential to governments, business, charities, and anyone looking to make intelligent predictions. The field requires strong mathematical skills, but what about people who need to make decisions about data, but who are not statisticians and programmers?

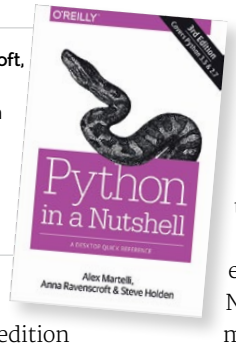
Ng and Soo's guide to *Data Science for the Layman: No Math Added* is a clear explanation of ten data analysis algorithms for supervised and unsupervised learning – plus one reinforced learning example – preceded by a basic look at data selection. Each algorithm is illustrated with a well-chosen data example, which is examined with illustrative graphs, clear text, and no mathematics, rounded off with a look at the limitations of the algorithm chosen.

From soccer penalties and obese giraffes, to PageRank and social networks applied to geopolitics and weapons sales, *Numsense!*'s examples illustrate and illuminate, but the real clarity comes from the direct writing style, and the authors' understanding of the subject matter. This book is not just for the non-technical reader – any programmer looking to understand data science and machine learning will quickly gain an appreciation of algorithms that other works introduce in a far less digestible form.

Score ★★★★★

PYTHON IN A NUTSHELL

Authors: Anna Ravenscroft, Alex Martelli, & Steve Holden
Publisher: O'Reilly
Price: £55.99
ISBN: 978-1449392925
magpi.cc/2ulYkoE



A long time in the making (the second edition was released more than a decade ago), the cover refers to this book as 'a desktop quick reference' – and it is the place to look up queries about Python, the standard library, and many parts of the Python ecosystem – but the size of this edition (more than 700 pages) is a heavyweight indicator of Python's growth.

O'Reilly's venerable nutshell series offers a comprehensive treatment of every topic – in this case Python for programmers coming from other languages, or those with a little Python who need to know more. Coverage is split between the basics (with plenty of detail on alternatives to standard CPython); core Python and the standard library; and a mixture of standard and extension libraries over topics such as databases, numeric processing, and dealing with testing and debugging.

Treatment is always detailed enough to get the job done. Network and web protocols make up the penultimate section; and the book is rounded off with extending, embedding, packaging, and the issues arising between versions 2 and 3 of Python. This may not be the book you'll use to learn the language, but put it on your shelf and you'll often reach for it as a reference text throughout the time that you use Python.

Score ★★★★½

ELECTRONICS COOKBOOK

Author: Simon Monk
Publisher: O'Reilly
Price: £39.99
ISBN: 978-1491953402
magpi.cc/2umkUBo

In the 1970s and 1980s, newsagents' shelves were stacked with titles like *Everyday Electronics* and *Practical Wireless*, and amateur electronic hardware knowledge would be applied everywhere from home hi-fi to DIY guitar pedals. A combination of pervasive computing and ready-made hardware devices costing pennies means modern Pi users are far more likely to be familiar with software than hardware. How to catch up on a mix of theory, component knowledge, and dozens of useful circuits?

Enter the ever-useful Simon Monk, with a cookbook that has the potential to become another O'Reilly classic. True, you'll need to make reference to the Errata page on the O'Reilly website, in particular for the first half dozen chapters; but this is a great collection of practical electronics know-how, nominally built around the needs of small board users, but essential for any learner.

The recipe format is stretched a little in the early chapters, to introduce theory and the basics of discrete components, but soon the recipes become mini-projects in themselves, and potential building blocks for all manner of Pi-based constructions. For old hands, it's nice to have all these circuits collected together – and your old reference books won't have this one's Pi and Python recipes.

Score ★★★★☆

KOTLIN IN ACTION

Authors: Dmitry Jemerov & Svetlana Isakova
Publisher: Manning
Price: From £20 (Amazon resellers only in the UK)
ISBN: 978-1617293290
magpi.cc/2vgdw9D

Kotlin is a JVM language from JetBrains, the people behind the IntelliJ IDEA Java IDE. Not the first language to attempt to fix the problems of Java (hello Scala!), but uptake has been swift, and we've heard praise for the language even from some notable Pythonistas. Kotlin is touted as a good replacement for Java in Android development – something of additional interest here, with Android Things running on the Pi 3.

This book is aimed squarely at Java developers: you don't need to be a Java expert to benefit from this very effective guide, but non-Java users should wait for a different Kotlin book. Jemerov and Isakova are Kotlin insiders. They make a persuasive case in the 'What and Why' chapter, before moving on to the basics of 'how' – emphasising the lack of boilerplate in examples such as declaring classes, and showing off the language's type inference.

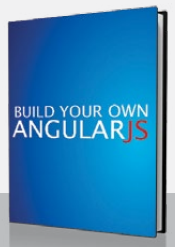
Classes are expanded in a chapter which highlights the differences from Java in interfaces. Improved function calls, adding methods to Java classes or interfaces, lambdas, and Kotlin's extensive type system round off the first half's language introduction. The second half gets you building your own APIs, using higher order functions, and using deeper features such as DSLs.

Score ★★★★☆

ESSENTIAL READING: BEYOND FRAMEWORKS

Frameworks can hinder understanding. Get to know the nuts and bolts of web development.

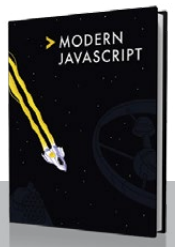
Build your own AngularJS



Author: Tero Parviainen
Publisher: Teropa
Price: £15.00
magpi.cc/2vKuoWA

A deep dive into the workings of a web framework, guiding you to better skills, and confidence in your knowledge.

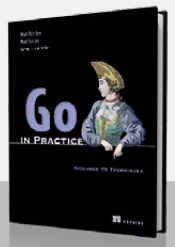
Modern JavaScript



Author: Various
Publisher: Sitepoint
Price: £5 or Sitepoint subscription
magpi.cc/2vgEgH1

Having trouble keeping up? Sitepoint's latest anthology is a quick introduction to the most important parts of the JS ecosystem.

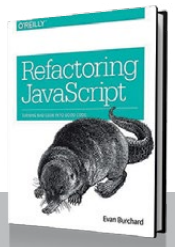
Go in Practice



Authors: Matt Butcher & Matt Farina
Publisher: Manning
Price: £27.99
ISBN: 978-1633430075
magpi.cc/2vj0JBA

Pattern-focused guide to the highly concurrent language that could solve your web app problems.

Refactoring JavaScript



Author: Evan Burchard
Publisher: O'Reilly
Price: £39.99
ISBN: 978-1491964927
magpi.cc/2vC59Gi

Refactoring and testing will turn bad code to good. Well-written and enjoyable read – strongly recommended.

Inclusive Design Patterns

Author: Heydon Pickering
Publisher: Smashing Magazine
Price: £27.00
ISBN: 978-3945749432
magpi.cc/2viJIYp

Best practices for pages accessible to all users, reconceiving web design as code- not pixel-based. Essential reading.

MOZILLA, IOT, AND THE RASPBERRY PI: AN INTERVIEW

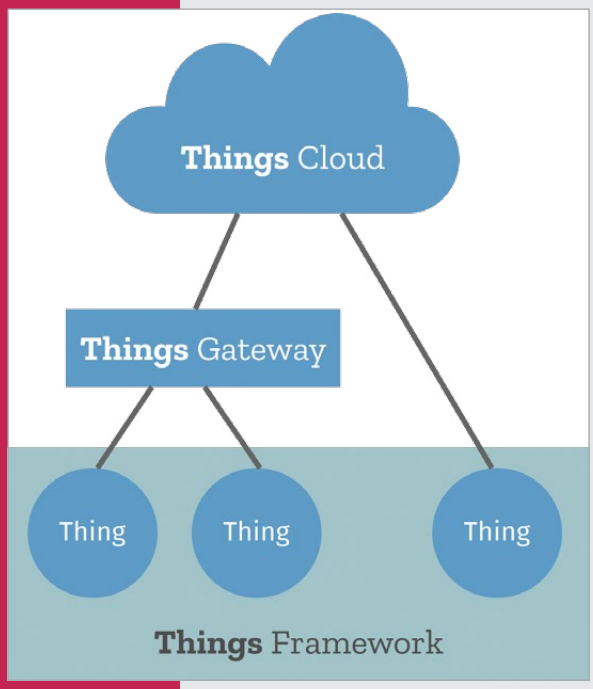
Project Things is a new framework involving Mozilla's Web of Things, and is now available on the Raspberry Pi. What exactly does this mean?

Benjamin Francis

Occupation: Software Engineer

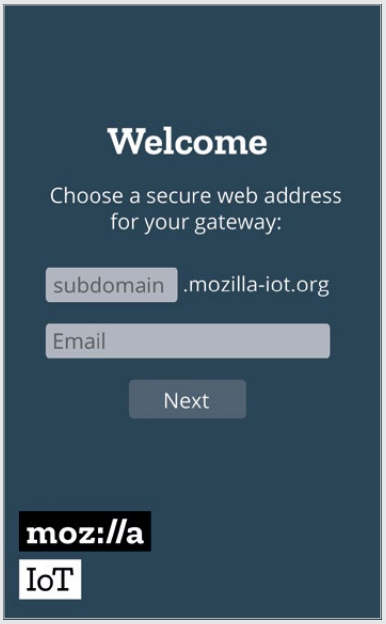
The maker community was abuzz with excitement when Mozilla announced Project Things last month, so we sat down with Benjamin Francis from the development team to talk about exactly what it means. Here's what he told us.

Can you explain what Project Things is?
Project Things is an experimental framework of software and services to help developers connect 'things' (physical objects in the real world) to the World Wide Web in a safe, secure and interoperable way. The project includes developing a 'Web of Things' gateway, which helps bridge existing IoT devices to the web; a collection of cloud services to help manage a large number of IoT devices over a wide geographic area; and a framework of reusable software components to help create IoT devices which directly connect to the Web of Things.



The first piece of the framework we've released is an early prototype of an open-source Web of Things gateway. Anyone can download the software image from Mozilla's website and build their own Web of Things gateway using a Raspberry Pi. The gateway enables users to choose a unique web address for their home without any complex DNS or router configuration, by using a secure tunnelling service provided by Mozilla. The gateway can then be used to monitor and control existing smart home devices like ZigBee and Z-Wave smart plugs and sensors, and access them remotely via a unified web interface.

Our initial demo showed how you can turn smart plugs on and off from a web app. We're now working with the community to add support for new types of devices and protocols via an adapter add-on system, and developing new components like a rules engine which can be used to define automated rules for how individual 'things' interact with each other (e.g. having a light turn on when a sensor detects motion).

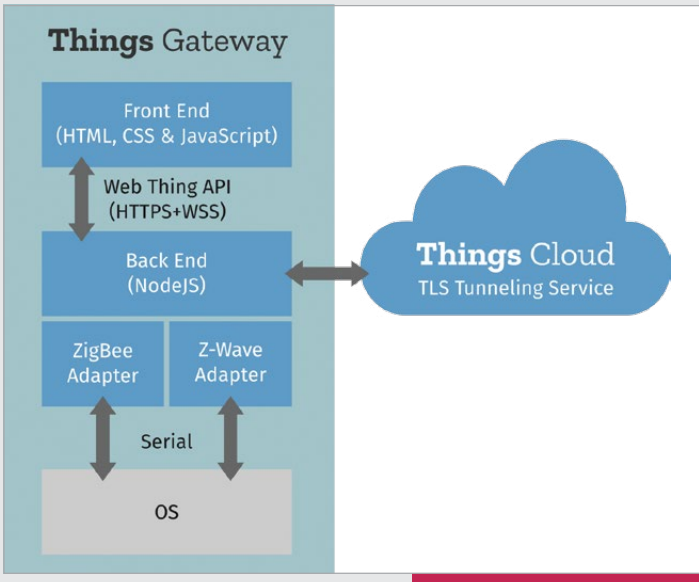


Above Project Things is easy to set up

Why the Raspberry Pi?
The Raspberry Pi 3 is affordable, easy to get hold of, runs Linux, and has wireless LAN and Bluetooth built in. This makes it an ideal hardware platform for the initial use cases – and the initial audience of DIY hackers and makers we're targeting with Project Things. We plan to support other hardware platforms in the future too, but the Pi was a great starting point for us.

Do you find it difficult to convey exactly what the IoT is to people?
People have diverse ideas about what the Internet of Things is, and there's really no single

mozilla IoT



accepted definition. It can range from sophisticated cloud-connected smart devices with artificial intelligence, to tiny RFID tags in smart packaging which give physical products an identity on the internet, used for inventory tracking or smart consumer experiences.

What makes IoT particularly confusing for end users is that because the technology is still in its infancy, there are no universally agreed standards for how connected devices should communicate. This means that there are lots of proprietary products and platforms available which can't talk to each other, so it's easy to get locked into a particular brand or cloud service.

> "The gateway enables users to choose a unique web address for their home"

At Mozilla we want to help educate users about the security, privacy, and interoperability issues around new IoT devices, while helping to define new standards for a decentralised Internet of Things which is safe and secure.

What is the Web of Things?

The Web of Things is an effort to take the lessons learned from the World Wide Web and apply them to the Internet of Things. It's about creating a decentralised Internet of Things by making Things linkable and discoverable on the web, and defining standard data models and APIs (application programming interfaces) to make them interoperable.

To put it simply, it's about giving Things URLs on the web.

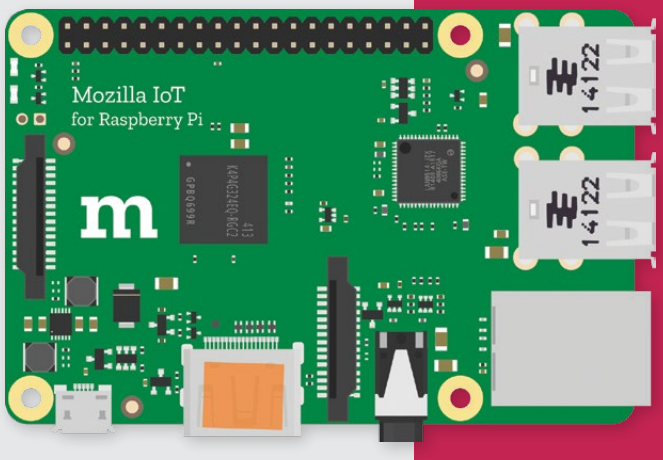
We're working with the W3C (World Wide Web Consortium) to help define standards for a decentralised Internet of Things, including a standard Web Thing description format to describe Things, and APIs to communicate with them. Project Things is Mozilla's open-source implementation of those proposed standards, but like all web standards, anyone is free to implement the specifications themselves in the programming language of their choice.

How can people get started?

Go to **iot.mozilla.org** to download our Things Gateway software image and follow the instructions to flash the image onto an SD card. You can then plug the SD card into your Raspberry Pi, plug in USB dongles for any additional wireless protocols you want to support, then access the gateway via your web browser to set up a secure web address for your home. You can pair devices like ZigBee and Z-Wave smart plugs with the gateway and control them from your browser using the built-in web app.

Project Things is an open-source project and we really encourage community contributions. There are lots of ways you can contribute, such as building your own IoT device which uses the proposed standard Web Thing API (**magpi.cc/2vMuYB9**), creating an adapter to bridge an existing IoT protocol or device to the web, or hacking Project Things itself to help us develop Mozilla's Web of Things implementation (**github.com/mozilla-iot**).

We're looking forward to seeing what the hacker and maker community can build with this software as it develops, and we'd love to hear about your DIY IoT projects!



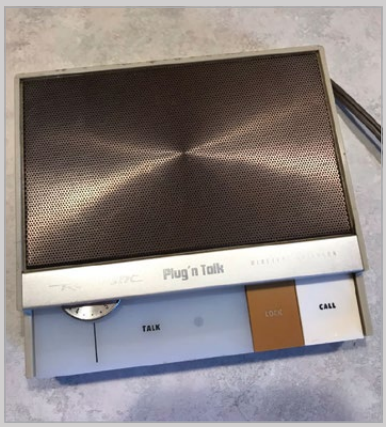
THE MONTH IN RASPBERRY PI

Everything else that happened this month in the world of Raspberry Pi

AIY INTERCOMS AND PHONES

For some reason, everyone's been using their AIY Projects Voice Kits in phones and intercoms this month...

Above Martin Mander's intercom project is retro and lovely



Another intercom?

magpi.cc/2vMSlL7

Already Martin is inspiring other makers. Here's another intercom voice project in the works, this time using Amazon Alexa. One day we'll have to run a comparison between the different voice assistant platforms. Perhaps we should have a retro intercom competition to decide it?

Earlier in this very issue, you'll have seen an amazing project that uses the AIY kit from issue 57 to hack an old-school intercom and turn it into a digital voice assistant. It's a wonderful project, and we always love seeing what Martin Mander is going to upcycle next.

Strangely, everyone else has been having the same idea! We saw loads of toy phones, intercoms, and other voice-powered products upgraded using AIY kits. Here are some of our favourites.

Kids' smartphone

magpi.cc/2vMuSty

This one is a little mean but honestly, we laughed. This Fisher-Price phone is a true classic and we love the idea of giving it a hefty upgrade with AIY, complete with a massive glowing button in the centre. Would it be creepy if you made it sing while the eyes moved? Very probably.

Operator!
magpi.cc/2vN4rE0

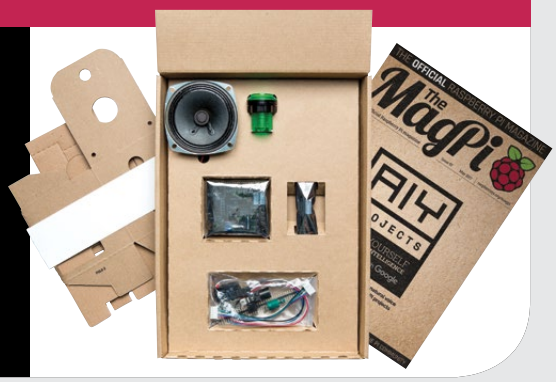
More retro upcycling with this old-school phone, upgraded to incorporate an AIY kit. Dial zero to talk to the assistant and get answers to your everyday queries. We have visions of someone picking it up and putting it under their chin to ask for ounce-to-gram conversions while they mix some batter, Nineties style.

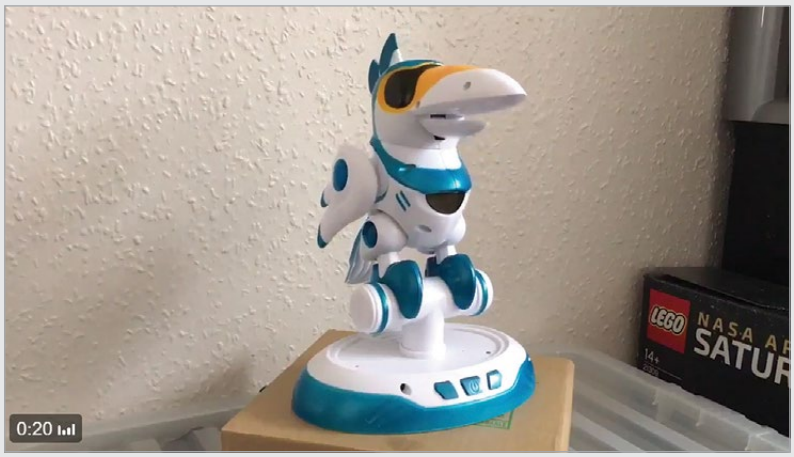
Toucan play at that
magpi.cc/2vMA6VP

This one is just fun. It's noise-activated, and the assistant voice really doesn't match its appearance. Maybe you could mod it so it has a Gilbert Gottfried voice? It also moves about as it speaks, adding to the Coolness Factor™.

HOW TO GET AN AIY PROJECTS VOICE KIT

Still waiting for an AIY kit? They're coming, we promise! The best way to find out more is to sign up to our mailing list – that way we can let you know as soon as they go on sale. You can sign up at **magpi.cc/Email-me**.





JAMS IN PICTURES

Pictures from the past month's Pi events around the world

Joel Marquez
@MarquezCHHS
Follow
Shhh! Geniuses at work! I've got an AWESOME team! #joustingbot #Picademy @Raspberry_Pi @cortlentz1 @ascollins @MsHaughs

twitter.com/Raspberry_Pi

twitter.com/tnmoc

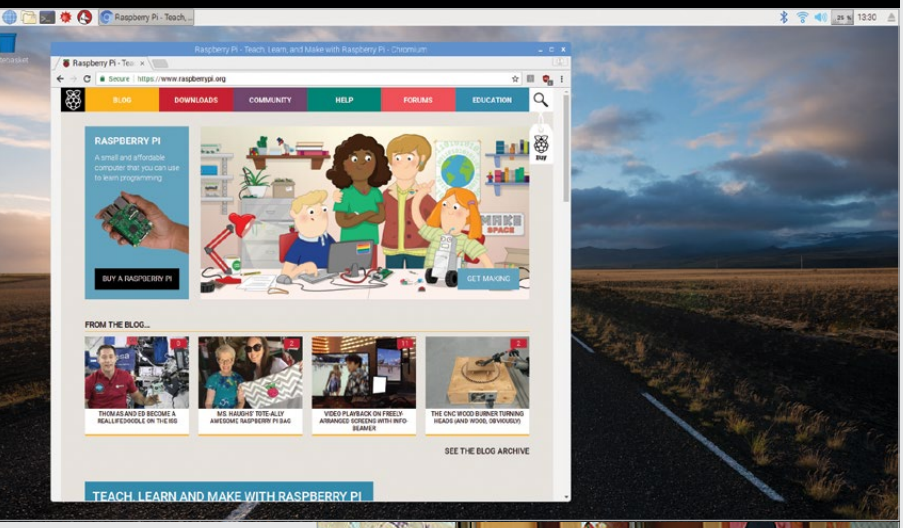
PICADEMY USA
Another successful Picademy took place in the USA, with some robo-jousting as part of the event.

THE NATIONAL MUSEUM OF COMPUTING
Some amazing projects were on display at The National Museum of Computing during its Raspberry Jam.

JAPANESE RASPBERRY JAM
Raspberry Pis are truly global! This robot recognises faces, and was shown off at a recent Jam in Japan.

NEW RASPBIAN STRETCH OUT NOW!

We got a massive Raspbian update this month – here's what you need to know about the latest Raspbian release



Right Debian releases are named after Toy Story characters. Stretch is an octopus toy from *Toy Story 3*, about whom you've probably forgotten after your heart shattered at the end...

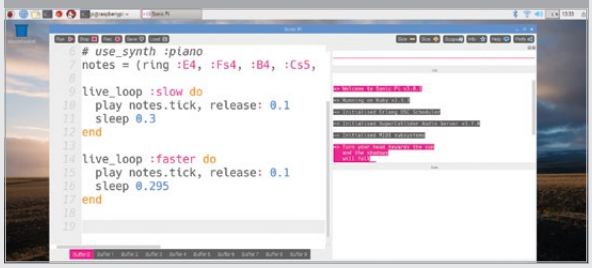
It doesn't seem very long ago that Raspbian Jessie came out. The successor to the original version of Raspbian, Jessie brought us a lot of minor upgrades and visual overhauls that are now a normal part of the Raspbian experience.

New Debian releases happen roughly every two years. Jessie came out in September 2015, so it's now time for Raspbian to upgrade to Stretch. The major upgrades this time are happening below the surface, so you shouldn't notice many differences when you're using the desktop. What you will find is upgraded software, including Chromium, and Bluetooth audio via ALSA, along with...

SONIC PI 3.0.1

Sonic Pi 3.0 boasts a lot of new features, including:

Time State	a powerful new time-based deterministic shared memory system
MIDI	support for input and output of MIDI
OSC	support for sending and receiving OSC messages on the network
Live Audio	for getting multiple streams of audio into Sonic Pi
Multi-channel audio out	for outputting multiple streams of audio
Audio Buffers	for internal recording of audio, enabling the creation of loopers



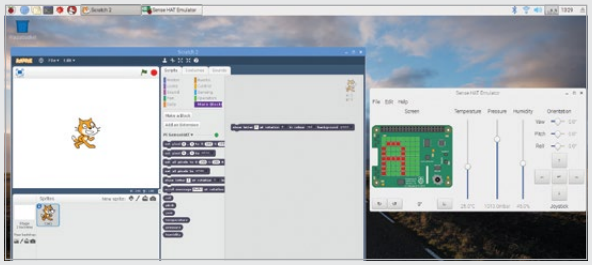
```
# use_synth :piano
notes = (ring :E4, :Fs4, :B4, :Cs5,

live_loop :slow do
  play notes.tick, release: 0.1
  sleep 0.3
end

live_loop :faster do
  play notes.tick, release: 0.1
  sleep 0.295
end
```

SCRATCH 2 SENSE HAT EXTENSION

Scratch was upgraded in the last Jessie release to Scratch 2, and this upgrade gives it the ability to interact with the Sense HAT. Hopefully this will introduce Scratch users to Astro Pi!



You can read a full guide to the new features of Raspbian Stretch on the Raspberry Pi blog: **magpi.cc/2w6uvfF**.

KICKSTART THIS!

Raspberry Pi projects you can crowdfund this month

BOBOP

magpi.cc/2vMzmQU

BOBOP is billed as 'the first smart robot for parents'. It looks a bit like the Mira bot project, featured earlier in this issue, although this one apparently keeps an eye on your kids. According to the creators, it was prototyped heavily with a Raspberry Pi, which is still being used as one of its main computers. You should just have enough time to give it a look before it ends.

SMARTIPI FLEX

kck.st/2uekNDb

This is a neat project. It's a special case for a Pi Zero and the Raspberry Pi Camera Module, with a flexible arm that holds the camera in a fixed position. It's a simple but great idea, allowing you to make some really cool camera-based projects. The campaign will have just finished by the time you read this, but hopefully it hit its target and you can pre-order one for yourself!

BEST OF THE REST

Here are some other great projects we saw this month

magpi.cc/2w6avKr

CNC WOOD BURNER

This is amazing. A spinning wood burner powered by a Raspberry Pi. It's cool, and it creates amazing results – everything we like to see in a Raspberry Pi project. It uses a hot wood burner pen rather than a laser, which is probably a lot safer.

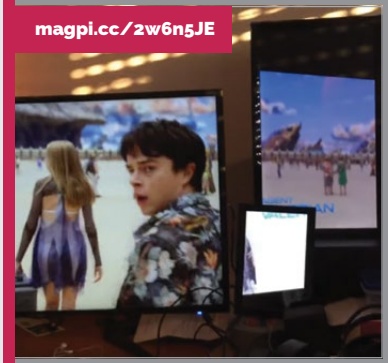
JEEP ACCELEROMETER

magpi.cc/2w5lKCU

When you have a big 4×4, and you regularly go off-road, you can experience some interesting angles while driving. Reddit user GoHomePortland made a display to track the pitch and roll while taking his Jeep off-road. Pointless? Probably. Cool? Absolutely.

AUTOMATIC VIDEO WALL

magpi.cc/2w6n5JE



An incredible feat of engineering, this project uses QR-like codes displayed on multiple different screens, which allow the software to calculate their locations, sizes, overlays, and angles. It then figures out how to piece the screens together into one large screen, and play a single video over all the screens so that it looks right. It's magic in action.

EVENT REPORT: CODE CLUB MEETUP

Educators gather in Cambridge to find out how they can take their Code Clubs further

Traditionally, Code Clubs are places for educators to teach kids about computer science. There are thousands of them around the world and they've helped countless students improve their computing skills through fun activities.

In Cambridge, in late July, a different kind of Code Club meeting took place. Volunteers and educators who run Code Clubs, along with prospective Code Club hosts, visited Code Club (and Raspberry Pi!) HQ to attend some talks, get to know other Code Club volunteers, and find out how to improve their Code Clubs.

"At the event in Cambridge, everybody had a chance to get hands-on with Code Club projects using pi-tops," said Sarah Sheerman-Chase, Participation Manager at Code Club. "Peter Onion, who is a volunteer at a club in Essex, demonstrated physical computing with micro:bits. There was also plenty of time for networking, and the opportunity to meet the team, including Mickey Day, the Code Club Coordinator for the East of England, and myself."

Right Peter Onion's demos drew crowds of people wanting to know more!

Plenty of demos were on hand for volunteers to try out and see what students could learn

While this was a relatively small event held in a conference room, it was pretty packed and full of excited Code Clubbers wanting to learn more and share their experiences. We saw many people getting to grips with some of the example projects on the pi-tops in the room, while others were wowed by Peter Onion's computing demos.

> "Everybody had a chance to get hands-on with Code Club projects using pi-tops"

A sea of volunteers

We spoke to Anne Worthington, who runs a Code Club at Cambridge Central Library, which has become very popular.

"It was a bit slow to begin with," Anne admitted to us. "Then, as soon as people knew what it was about, we started filling up a waiting list and we managed to satisfy those requests to get on board."

It began with a taster session, held in partnership with a sister event in Huntingdon. The club eventually started in the middle of the school term with a focus on Scratch and Python.

"Those who had done Scratch could move onto Python," explained Anne. "The volunteers thought it was a good way of engaging them beyond Scratch. Now we've finished this academic year and they've all said how much they've enjoyed it. The volunteers are doing fantastic work."

We always hear about Code Clubs being constantly full, and how kids really enjoy them, and Anne's club was no different. "We've had a very successful year, with a full complement of 14 or so children at each session. A bit up and down with holidays and family life, but it was just joyous seeing how much better the children got at the activities. We have similar Code Club activities running in Huntingdon and St Neots, and we're looking to expand to libraries out in The Fens as well."

Choose your own adventure

One of the volunteers for the Cambridge Central Library Code Club, Krishna Kumar, helped develop learning resources for the micro:bit, which the club plans to use – a hot topic of discussion at the event.

He also helps out in the Code Club sessions, revealing that their club has a far better gender ratio than the tech workforce as a whole, with girls making up between 35 and 40 percent of their attendees.

He feels the courses have a great deal of choice in them, allowing every participant to create projects based on their own interests.

After munching on some pizza, it was time to head home, but everyone seemed to leave with new ideas and inspirations to start or improve their Code Clubs.

START A CODE CLUB

You don't have to attend meetups to start your own Code Club – you can find all the information you need on the Code Club website at **codeclub.org.uk**. Learning resources are free – all you need to do is find a venue with computers!

COMMUNITY PROFILE

DAVE AKERMAN

High-altitude balloonist and master of LoRa, Dave likes to send Pis as high as the atmosphere will allow

Dave

Category: High-altitude balloonist

Day job: HAB enthusiast/ software engineer

Website: daveakerman.com
twitter.com/daveake

The pinned tweet on Dave Akerman's Twitter account shows a table displaying the various components needed for a high-altitude balloon (HAB) flight. Batteries, leads, a camera and Raspberry Pi, plus an unusually themed payload. The caption reads 'The Queen, The Duke of York, and my TARDIS', and sums up Dave's maker career in a heartbeat.

Though writing software for industrial automation pays the bills, the majority of Dave's time is spent in the world of HAB and the ever-growing community that encompasses it. And, while he makes some money sending business-themed balloons to near-space for the likes of Aardman Animations, Confused.com and the BBC, Dave is best known in the Raspberry Pi community for his use of the small computer in every payload, and his work as a tutor alongside the Foundation's staff at Skycademy events.

Dave has dedicated many hours and many, many more miles to assisting with the Foundation's Skycademy programme, helping to explore HAB with educators from across the UK. Using a Raspberry Pi and various other pieces of lightweight tech, Dave, and Foundation staff member James Robinson, explored the incorporation of high-altitude ballooning into education. Through Skycademy, educators were able to learn new skills and take them to the classroom, setting off their

Below Dave continues to help others while breaking records and having a good time exploring the atmosphere

Dave doesn't just launch balloons for fun. With clients such as the BBC and Heston Blumenthal, he's launched all manner of items into space… including a potato!

HIGHLIGHTS

magpi.cc/2vXHvEx

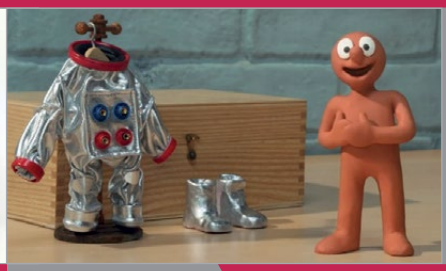
WHERE NO PI HAS GONE BEFORE

Dave is recognised as being the first person to incorporate a Raspberry Pi into a HAB payload, and continues to break records with the help of the little green board. More recently, he's been able to lighten the load by using the Raspberry Pi Zero.

magpi.cc/2vXfb5e

PI IN THE SKY

When the first Pi made its way to near-space, Dave tore the computer apart in order to meet the weight restriction. The Pi in the Sky board was created to add the extra features needed for the flight. Since then, the HAT has experienced a few changes.



magpi.cc/2vXDUGi

MORPH IN SPACE

One of the many commercial flights Dave has organised featured the classic children's TV character Morph, a creation of the Aardman Animations studio known for Wallace and Gromit. Morph took to the sky twice in his mission to reach near-space, and finally succeeded in 2016.

own balloons with their students, and recording the results on Raspberry Pis.

But education isn't the only reason for Dave's involvement in the HAB community. As with anyone passionate about a specific hobby, Dave strives to break records. The most recent record-breaking flight took place on 13 August 2017, as Dave's Raspberry Pi Zero HAB sent home the highest images taken by any amateur high-altitude balloon launch. At 43,014 metres, no other HAB balloon has provided images from such an altitude, and the lightweight nature of the Pi Zero definitely helped, as Dave went on to mention on Twitter a few days later.

Dave first fell in love with high-altitude ballooning after coming across the hobby as a video shared on a photographic forum. With a lifelong interest in space thanks to watching the Moon landings as a boy, plus a talent for electronics and photography, it seems a natural progression. Throw in his coding skills from learning to code on a Teletype and it's no wonder he was ready and eager to take to the skies, so to speak, and capture the curvature of the Earth. What was so great about using the Raspberry Pi was the instant gratification gained when receiving images in real-time as they were taken during the flight. While other devices could operate a camera and store the photographs for later retrieval, Dave was able to transmit them back down to Earth and check the progress of his balloon while attempting to break records with a flight.

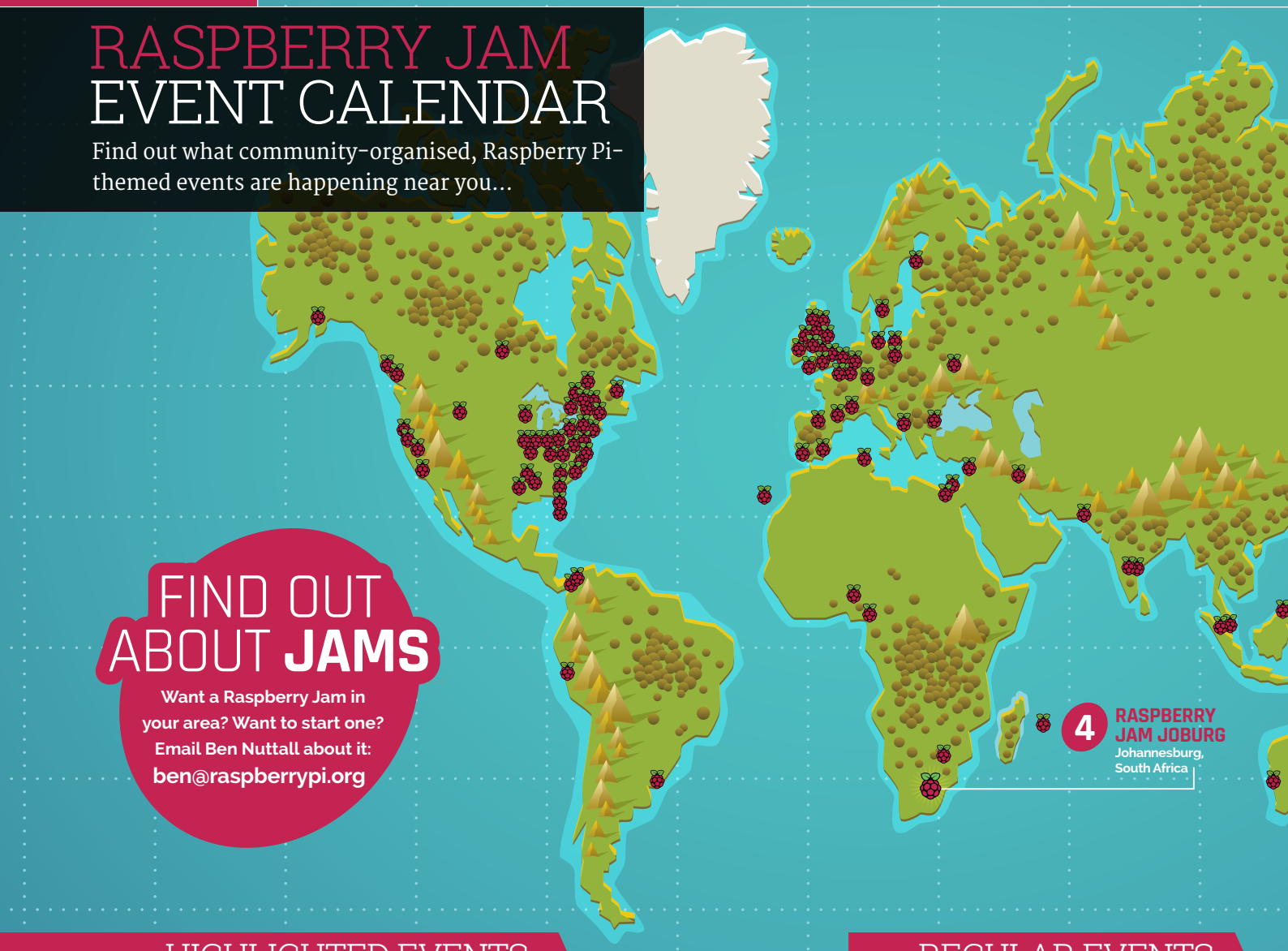
> "As with anyone passionate about a specific hobby, Dave strives to break records"

High-altitude ballooning isn't the only part of Dave's life that incorporates a Raspberry Pi. Having "lost count" of how many Pis he has running tasks, Dave has also created radio receivers for APRS (ham radio data), ADS-B (aircraft tracking), and OGN (gliders), along with a time-lapse camera in his garden, and a few more for tinkering purposes.

Dave's most recent flight broke a new record. On 13 August 2017, his HAB payload was able to send back the highest images taken by any amateur flight

RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...



FIND OUT ABOUT **JAMS**

Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall about it:
ben@raspberrypi.org

HIGHLIGHTED EVENTS

1 TECHNO JAM

When: Saturday 9 September
Where: Southport College, Southport, UK
technojam.uk
An event for people who are interested in all forms of technology to come together and share their knowledge.

2 GUILDFORD RASPBERRY JAM

When: Saturday 16 September
Where: Guildford Library, Guildford, UK
magpi.cc/2xawKf1
Learn about Raspberry Pis, get help from others, show off your projects, and meet other Raspberry Pi fans.

3 JAMMING IN MARLBOROUGH

When: Saturday 16 & 23 September
Where: Marlborough Library, Marlborough, UK
magpi.cc/2xa25yq
Drop in to Marlborough Library on Saturday morning to see Raspberry Pis being used in a variety of ways.

4 RASPBERRY JAM JOBURG

When: Saturday 16 September
Where: Entelect, Johannesburg, South Africa
magpi.cc/2wgrJVW
You'll get the opportunity to demonstrate your Pi project and discuss it with other like-minded Pi enthusiasts.

REGULAR EVENTS

5 CORNWALL TECH JAM

When: Saturday 9 September
Where: Cornwall College Camborne, Redruth, UK
cornwalltechjam.uk
For all ages and abilities: ask questions and learn about programming in Scratch, Python, Minecraft, and much more.

6 HULL RASPBERRY JAM

When: Saturday 9 September
Where: Hull Central Library, Hull, UK
magpi.cc/2wgiUv8
There'll be chances to get hands-on with digital making activities through workshops, and a hackspace area to share projects and give lightning talks.

7 MANCHESTER RASPBERRY JAM

When: Saturday 9 September
Where: The Shed, Manchester, UK
magpi.cc/2wgeAMp
A very long-running Jam that celebrated its fifth birthday in June of this year, finally back from its summer hiatus.

8 RASPBERRY JAM @ PI TOWERS

When: Saturday 16 September
Where: Raspberry Pi HQ, Cambridge, UK
magpi.cc/2wgBoxb
A family-friendly event where everyone is welcome, providing coding and digital making activities for children and adults.

RASPBERRY JAM ADVICE

FINDING VOLUNTEERS

> "You'll find that a lot of the people who attend your first Jam will become your future volunteers"
>
> **Mike Horne**
> Cambridge Raspberry Jam

Every Raspberry Jam is entitled to apply for a Jam starter kit, which includes magazines, printed worksheets, stickers, flyers, and more. Download the book here: **magpi.cc/2q9DHfQ**.

YOUR LETTERS

Above You can find out how to burn an SD card with Etcher on a PC by following our video tutorial: magpi.cc/2sj7leN

Maker Faire New York

I see *The MagPi* attends some events in the UK, such as the birthday parties and Pi Wars. I understand you're a UK-based magazine. However, I was wondering if your team would be making an appearance at a US Jam or event of some sort? Would love to meet you guys!
Angela L

We don't exhibit at events often enough, really! It's fun and great to meet people, but it does take a lot of time. Having said that, if you're at Maker Faire New York this September, some *MagPi* team members will be helping out at the Raspberry Pi stall, so if you're attending you can come and see us. Even if you can't get to New York, you can usually find some *MagPi*-related goodies on Raspberry Pi stalls at events across the USA.

Etcher on Pi

I followed the instructions in the article about how to use Etcher with Raspberry Pi SD cards. However, I am unable to make it work. I used the code below:

```
cd Downloads
chmod a+x Etcher-linux-x64.AppImage
./Etcher-linux-x64.AppImage
```

I get an error and I am unable to make Etcher run. The error is: 'cannot execute binary file: Exec format error'. Can you help?
CuteCobra

Unfortunately, Etcher doesn't work on the Raspberry Pi: the packages you can download for Linux are either x86 or x86_64, which are meant to run on a normal PC – in this case a normal PC running Linux.

You can't burn a downloaded Raspbian image to another SD card on the Raspberry Pi in the same way as using Etcher on a PC. However, with the SD Card Copier tool in Raspbian, you can make a copy of your current SD card to another SD card connected via a USB card reader. The software will guide you through the process.

The article this reader is referring to can be found here: **magpi.cc/2fZkyJD**.

GETTING THE AIY PROJECTS VOICE KIT

We're still getting emails from a lot of people asking how they can get their hands on issue 57 or the AIY Projects Voice Kit that came with it. We're adding a boxout here to remind everyone that the kit will be going on sale on its own soon. To find out when the kits will be available, sign up to our mailing list at **magpi.cc/Email-me**. That way, we can let you know as soon as we have a date for the release of the kits.

FROM THE FORUM: ISO ISSUES

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community. Join in via **raspberrypi.org/forums**

I have just received the latest *The MagPi* #60, and was delighted to find the attached Raspberry Pi Desktop x86 DVD. Unfortunately I then realised I hadn't bothered adding a DVD drive to my new computer. My intention was to run it in VirtualBox, so ideally I just need an ISO image.

Where would the best place be to download the latest version of the ISO image (happy to do so as a torrent)?

Quite a few blogs from last year point to another image but I found a different one that seems to be more up to date.

Is the latest one safe to use? How do I know it's safe?

Many thanks,

CraigT

For future reference, you can easily find the ISO of the latest x86 Raspberry Pi Desktop build by going to **rpf.io/x86**, set up by Raspberry Pi Community Manager Ben Nuttall. The one you pointed to in the forum thread was the latest version. As a general rule, if they're hosted on the Raspberry Pi website, they're safe to use. If they're beta release or some other form of non-stable release, they will be labelled as such.

WRITE TO US

Have you got something you'd like to say?

Get in touch via **magpi@raspberrypi.org** or on *The MagPi* section of the forum at: **raspberrypi.org/forums**

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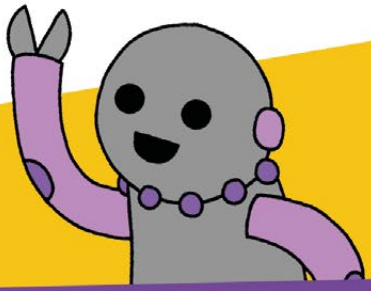
{code club}



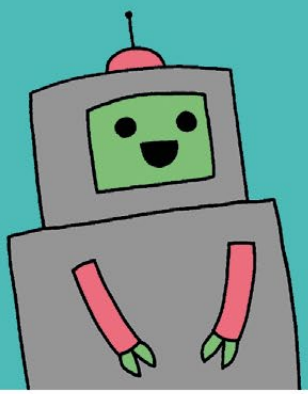
START A CODE CLUB IN YOUR SCHOOL!

Code Club is a network of volunteers and educators who run free coding clubs for young people aged 9-13.

Our aim is to inspire the next generation to get excited about computer science and digital making.

"We use Code Club's fun educational resources to run a weekly after-school club for Year 7 and Year 8 pupils. The students benefit considerably from the extra challenge!"

Karen Dadd, Computing Teacher



- **Code Club is free**
- **Code Club provides step-by-step guides for Scratch, Python, HTML, and Sonic Pi**
- **Code Club helps children develop skills including logical thinking, creativity, and resilience**

We have over 6000 clubs across the UK teaching more than 80,000 young people to code—come and join us!"

Find out more at www.codeclub.org.uk

Code Club is part of the Raspberry Pi Foundation. Registered Charity Number 1129409

IN ASSOCIATION WITH: The PiHut www.ThePiHut.com

WIN!

RASPBERRY PI 3 RETRO GAMING BUNDLES

We've got three Raspberry Pi 3 retro gaming bundles up for grabs, worth £65 each.

Not only that, 15 lucky runners-up will get a SNES-style Raspberry Pi game pad.

These great prizes are courtesy of The Pi Hut: thepihut.com

The Raspberry Pi makes the ideal retro gaming console. Pi Hut's retro gaming bundle has everything you need to build your retro console. It comes with a Raspberry Pi 3 computer, black case, 16GB microSD card, official Raspberry Pi power supply, HDMI cable, and two SNES-style game pads.

Learn more about the retro gaming bundle at magpi.cc/2uY6K9Y

Enter now at magpi.cc/WinSep17

Terms & Conditions

Competition opens on 30 August 2017 and closes on **28 September 2017**. Prize is offered to participants world-wide aged 13 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram or Facebook.

MATT RICHARDSON

Matt is Raspberry Pi's US-based product evangelist. Before that, he was co-author of *Getting Started with Raspberry Pi* and a contributing editor at *Make:* magazine.

RASPBERRY PI AND MICROCONTROLLERS: A POWERFUL PAIRING

Matt Richardson's take on how two popular technologies work together

When I first joined the maker movement in 2010, microcontrollers such as Arduino were already an indispensable tool for making things with technology. I used Arduino in many of my projects because it was so easy to program, and there was a ton of easy-to-follow examples and community support available. At the time, some of my projects involved operations such as saving data and hosting a web server, which would push any microcontroller of that era to its limits.

Therefore, when maker-friendly single-board computers like Raspberry Pi came onto the scene, I started to think a lot about how their powerful processors would be useful for more advanced projects. Coupled with the on-board general-purpose input and output pins, it meant makers had new tools at their disposal to push the boundaries of what's possible for their projects.

There's a lot of overlap in the functionality of a single-board computer and a microcontroller. Both have the ability to run code and interface with electronics. The strength of a single-board computer lies in its ability to do 'high-level' tasks, such as running web servers, writing to databases, capturing photos, executing computer vision algorithms, playing audio and video, and so on. Microcontrollers have their strengths as well. For example, they're good at sending signals with precise timing, which is important for controlling some types of motors or addressable LEDs. Other advantages include their low energy consumption, their quick start-up time, and often they have built-in analogue input capability.

Working together

As a maker, having both microcontrollers and single-board computers in your toolbox means you can accomplish a broader range of projects. Choosing the right type of board based on your project's needs is an important skill for a maker, but that doesn't necessarily mean that you'll choose one or the other. A single-board computer can work well with a microcontroller in a unified project.

A simple serial communications connection between a Raspberry Pi and Arduino means that the two boards can talk to each other and pass data back and forth. For example, if you were making your own pen plotter, you may have a microcontroller controlling the stepper motors which move the pen. The data could be fed to the microcontroller by a single-board computer, which shows a user interface on a screen or via a built-in web server.

> "Their strong interoperability opens up so many possibilities"

The way that the two platforms work together doesn't stop there. A microcontroller isn't very useful if you don't have a computer to write the code and upload it to the board. Luckily, the Arduino's development environment runs nicely on Raspberry Pi's Raspbian operating system. So even if your project doesn't call for anything more than a microcontroller, why not use your Raspberry Pi to program it?

Contrary to what some may believe, microcontrollers and single-board computers aren't competitors, but partners. While there's a lot of overlap in the functionality of both types of devices, they're both great tools to have in your maker toolbox. Their strong interoperability opens up so many possibilities for rather complex projects. When you make with both microcontrollers and single-board computers, the whole is greater than the sum of the parts – and that makes them a powerful pair.

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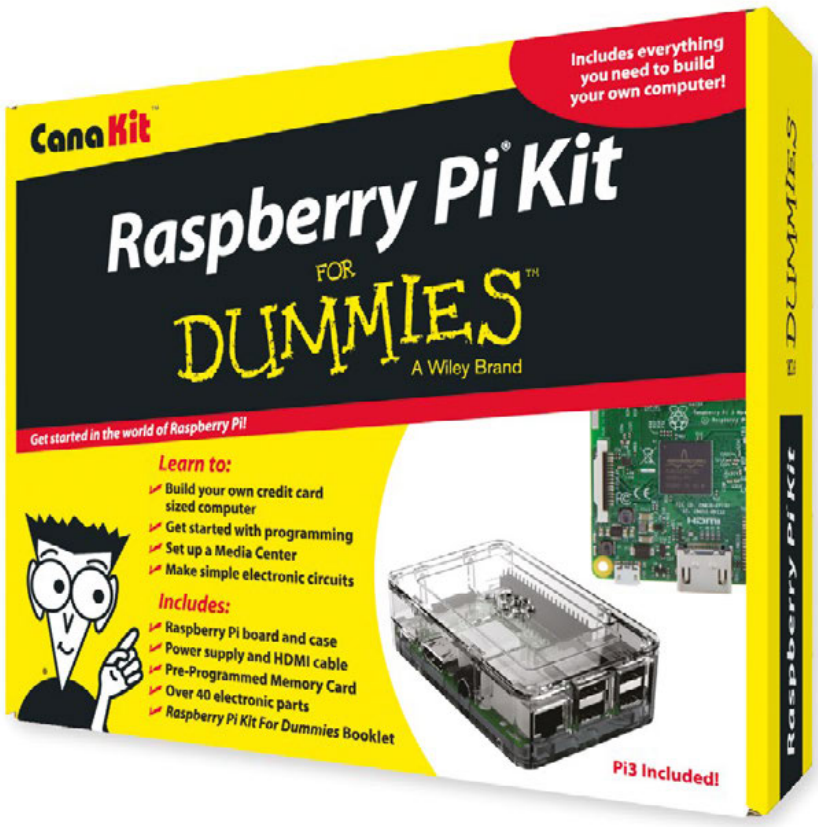

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